

LIQUID AND GASEOUS OXYGEN SAFETY REVIEW

FINAL REPORT CASE FILE Vol. II JUNE 1972

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Prepared for

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Final Report

Volume II of Four Volumes

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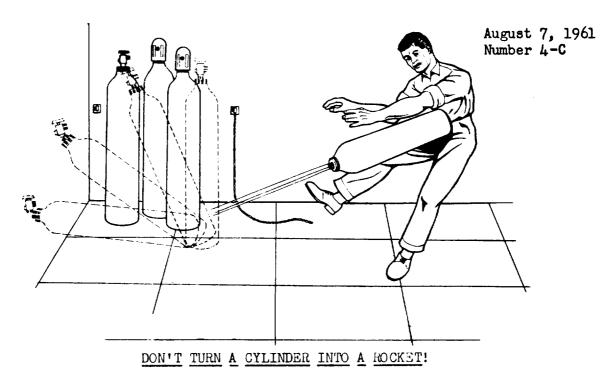
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TABLE OF CONTENTS

	VOLUME	PAGE
Acknowledgments	I	i
Abstract	I	ii
Introduction	I	1
Organization of Report	I	5
Recommendations for Research and Development	I	7
Index to Liquid and Gaseous Oxygen Safety Review Forms	I	11
Liquid and Gaseous Oxygen Safety Review Forms IAla-1 to V-4	I	
General Index	I	
References: Doc. # 99000001 to 99000160	II	
Doc. # 99000161 to 99000320	III	
Doc. # 99000321 to 99000601	IV	

Air Products and Chemicals



A standard 250 cubic foot cylinder pressurized to 2500 PSIG can, after a cylinder valve is broken off, become a rocket attaining a speed of 34 miles per hour in one-tenth of a second after venting from the broken cylinder connection:

The following precautions should be taken to prevent accidents with cylinders:

- 1. When storing cylinders, secure them to a wall or vertical support by means of restraining straps, chains, etc.
- 2. When moving cylinders, use a cylinder cart with the chain restraint in place. Do not drag cylinders.
- 3. Valve protection caps should be installed on cylinders at all times when not in use.
- 4. Cylinders should never be dropped or rolled in a horizontal position as the cylinder valve might be broken off.
- 5. Return leaking cylinders to personnel authorized to make repairs as soon as possible.
- 6. Segregate cylinders in storage as to type of gas, empty or full, and maintain oxygen cylinders a minimum distance of 20 feet from flammable gas cylinders unless separated by a fire resistant wall.
- 7. Smoking is prohibited in the vicinity of cylinders containing flammable gases or oxidants.

NOTE: Items 1 and 2 above do not apply to cylinder charging facilities.

APCI DOCUMENT NO 9900000/

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October 20, 1961 Number 5

Fire in Oxygen Line

On August 23, 1961, shortly after preparations had been made to put the oxygen cylinder charging facility on stream, a fire originated in a stainless steel high pressure oxygen line at the Cleveland facility. The fire was confined to approximately 14 inches of piping, and fortunately, there were no injuries as a result of the fire.

The cylinder charging facility was supplied by liquid product from the tonnage plant by means of a DRI pump, a booster pump, and a vaporizer. Upon completion of piping, the system had been pressure tested two times at 1800 psig. Prior to the fire, the block valve on the vaporizer discharge was closed as was the main block valve on the oxygen charging manifold. Thirty-eight of the fifty cylinders on the charging manifold were partially filled with oxygen. The DRI pump was started, but stopped pumping when the booster pump lost its prime. The DRI pump was shut down and the pressure relieved in preparation for additional pump cool down. Following this, the vaporizer discharge block valve was opened; however, back flow through the line is prevented by a check valve downstream of the vaporizer. The main block valve on the charging manifold was opened and seconds later a loud report was heard.

Investigation of the noise revealed a section of the stainless steel line between the vaporizer and charging manifold had ruptured due to an internal fire in the line. The pressure gauge on the charging manifold indicated 550 psi after the fire. Further investigation found the line contained oil to an extent that, upon cutting the line, oil was observed dripping from the cut. Also, a 1/2 inch mild steel rod was found with the hex head lodged in an elbow. The original length of the rod could not be determined as the rod had burned, contributing additional full to the burning oil in the line. The source of ignition might very possibly have been a spark resulting from movement of the steel rod in the pipeline.

The question as to how the rod and oil entered the piping system has not been answered. It would appear to be a mischievous prank or a grudge held by subcontractor's personnel. In any event, the consequences of a contaminated oxygen system are exemplified in the above incident. All personnel associated with the installation of air separation plant equipment and oxygen piping systems should constantly be on the alert to prevent contamination of the system whether accidental or intentional. The purging of a piping system is important to remove weld slag and other foreign material and in addition to detect, if possible, any blockage of the system by erratic movement of the pressure gauge.

SAFETY DEPARTMENT FKKitson/jmf

Air Products and Chemicals

November 17, 1961
Number 6

Number 6

Ni Production Oxygen
Lioun Oxygen

Lioun Oxygen

Liquid Oxygen Loading

- 1. Do not start an engine or drive a motor vehicle in a heavy concentration of venting oxygen. Fuel is always present in the form of oil and grease accumulations on the engine, and the insulation of the electrical system. Ignition can take place due to frayed insulation resulting in an electrical spark or a hot exhaust manifold. Several years ago a vehicle was severely damaged at the Denver facility due to a fire when oxygen vapor collected under the hood of a vehicle and the engine was started.
- 2. Check the area in the vicinity of the trailer loading station prior to transferring liquid oxygen to insure the area is clear of flammable materials.
- 3. Wear personnel protective equipment as required, a minimum of chemical goggles and gauntlet gloves, when transferring cryogenic liquids. Observe "No Smoking" regulations in liquid oxygen loading areas. If clothing has been exposed to concentrations of venting oxygen and clothing cannot be changed, do not smoke for one-half hour until the oxygen has dissipated. Remain in a well ventilated area and slap clothing to assist dispersion of oxygen vapor from clothing.

SAFETY DEPARTMENT FKKitson/jmf

APCI DOCUMENT NO 2900003

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October 25, 1963 Number 10 Revision 1

Approved Alloy Steels in Cryogenic Service

It is possible a "near miss" was averted at the Weirton facility when a carbon steel stud and nuts bolting the bonnet on a check valve were replaced with a 300 series stainless steel. The check valve was located in the discharge line from the liquid oxygen E-J pump. A serious condition could have resulted if the bolting on the bonnet had failed due to a brittle fracture thereby releasing high pressure liquid oxygen inside the pump box.

During maintenance work, it is good practice to check material to be installed in cryogenic service to determine if the steel is acceptable. Also, if rust is detected on existing steel in cryogenic service during maintenance work, a check should be made to insure the steel is an approved type (18-8 or 9% nickel steel). Austentic stainless steels, such as 304, 316, and 347 (the 18-8 stainless steels) are nonmagnetic. Although an 13-8 stainless steel can exhibit slight magnetic properties, there should be no problem differentiating between a carbon steel or an 18-8 series stainless steel. The 400 series stainless steels and 9% nickel steels are magnetic as are the carbon steels; however, the 400 series stainless steels are not specified for cryogenic service, and 9% nickel steel is utilized in only a few applications.

A test to differentiate between carbon steel and a nickel steel is as follows:

- 1. Place a few drops of 1:1 nitric acid (1 ml. of concentrated nitric acid to 1 ml. of water) on the specimen and allow to react. (Surface should be cleaned of mill scale, oil, grease, and dirt.)
- 2. Neutralize the acid with a slight excess of zinc oxide. For best results, the zinc oxide should be mixed with water to form a fluid slurry.
- Add a few drops of standard dimethylglyoxime solution (a saturated solution of dimethylglyoxime solution in 95 percent ethyl alcohol).

A definite pink color shows the presence of nickel. Small pieces of 9% nickel steel and carbon steel should be available as standards for comparison when conducting the test.

The possibility of a vendor supplying carbon steel or cadmium-plated carbon steel in place of an 13-8 stainless steel, even though the engineering and purchasing specifications are explicit, does exist. A similar condition could also arise with bolted bonnet gate and globe valves. To reduce the possibility of a similar occurrence, it is recommended that any questionable steel valve, bolting device, or other equipment for cryogenic service shall be checked to determine if the steel is acceptable.

SAFETY DEPARTMENT FKKitson/jf

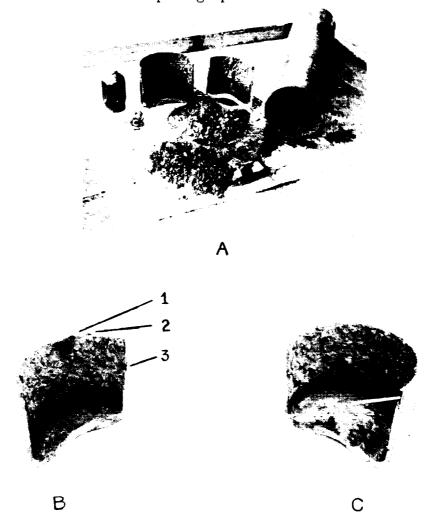
APCI DOCUMENT

Oxygen Cylinder Failure

June 1, 1962 Number 13

A near miss occurred recently at one of our cylinder filling facilities. An oxygen cylinder, fully charged, was being rolled to the storage area when the oxygen released through a small hole in the side of the cylinder about six inches from its base. Along with the oxygen discharging from the cylinder, about one quart of water also discharged from the hole.

The cylinder was sectioned and the photographs below show its internal condition.



Photograph A, taken immediately after the cylinder was sectioned, shows the scale, muddy water, and residue removed. Several pieces of eroded metal were as large as two inches square. Approximately 13 pounds of loose material was removed.

Photograph B shows the lower seven inches of the cylinder. The dark areas were cleaned of scale, and represent a reduction of metal thickness of approximately 1/16". Points 1, 2, and 3 are eroded areas where the wall metal remaining is less than 1/16", slightly more than 1/16", and 1/8" respectively. The normal wall thickness of a cylinder is about 1/4".

Photograph C shows a pipe cleaner inserted in the hole where the leak occurred. Originally, the hole was not visible on the outside surface of the cylinder. The point of a pocket knife used to clean the scale from the area of the leak actually punctured the wall and increased the hole size to approximately 1/8 inch

There are two reasons for this cylinder failure.

1. The user of the cylinder did not exercise sufficient care in handling the cylinder by allowing it to be exposed to wet weather or other water sources and by not closing the valve when the cylinder was empty.

2. The cylinder filling facility did not exercise adequate inspection procedures

prior to refilling the cylinder.

Here are two ways to prevent this type of cylinder failure:

1. Instruct the user to close the valve when the cylinder is empty to prevent water from entering, or allow a slight positive pressure to remain in the cylinder to prevent any contamination from entering. Special treatment and handling is then not required at the cylinder filling locations.

. Give each cylinder a hammer test before filling. The Compressed Gas Associa-

tion Pamphlet C-1, page 17, paragraph 2.3 states that:

"An empty cylinder before recharging should be examined for physical damage and exterior corrosion, followed by hammer test. Those cylinders which have a dull or peculiar ring when tapped with a hammer should be carefully examined and, if necessary, valves removed and interior examined with suitable light and retested before charging."

This information also appears in the cylinder hydrostatic instruction book. A convenient method of hammer testing each cylinder can be accomplished, after the cylinders have been attached to the charging manifold pigtails, and before starting to refill them, by tapping each cylinder with the end of the cylinder wrench in a similar manner as a small boy would run a stick along the boards of a picket fence. A dull or peculiar ring sound to a cylinder is a strong indication that something is wrong and should be internally inspected before filling.



October 29, 1962 Number 21

Isolation of Piping Systems

In April of this year a near accident occurred at the 170 T/D Granite City plant when a carbon steel line ignited during the welding of a nitrogen reactivation line. Precautions had been taken to isolate the system and purge the line; however, the blower supplying the purge was interrupted and a leaking valve permitted a flow of oxygen into the pipe resulting in a burnout four inches long and two inches wide before being extinguished with a $\rm CO_2$ extinguisher. Fortunately no injuries occurred as a result of this incident, although it illustrates the necessity for caution in the isolation of systems.

There are primarily two methods of positive isolation of piping systems with different methods utilized depending on the operation to be performed. It is common knowledge that one shut-off valve will not result in positive system isolation.

One method that is used is the use of double block and bleed valves. This type of system isolation is provided to prevent backflow of oxygen in hydrocarbon or guard adsorber reactivation lines or in pump defrost (heated) lines. Also, blocks and bleeds are provided to prevent oxygen leakage into a drier reactivation circuit on soap lubricated oxygen compressing systems. Blocks and bleeds are provided for these services and should be utilized whenever applicable to prevent an undesired flow due to leakage of a shut-off valve, to a heater, or heated reactivation circuit.

A second method of system isolation is the use of blind flanges or blanks inserted in flanges during maintenance repairs such as involving hot work. If blanks are used, a blanking material must be selected that is adequate for the pressures involved. Care must be taken that the point of blanking does not eliminate a safety relief device on the remaining system. The use of double blocks and bleeds or removal of pipe spools or fittings to guard against leakage during hot work should be approached with caution. The removal of a section of line should be adequate to prevent flow across the open section of piping. The pipe should be checked with a Beckman oxygen analyzer to detect any abnormal oxygen concentration. Safety work permits and tag-outs should be used prior to commencing work.

SAFETY DEPARTMENT FKKitson/jmf

January 10, 1963 Number 23-C

GASEOUS OXYGEN

GENERAL

Oxygen very readily supports combustion. Materials which burn easily in air usually burn more violently in oxygen. Equipment used in oxygen service, therefore, must be designed to eliminate, where possible, materials that are not compatible.

Vessels and piping used in oxygen service should be designed to ASME Code for the pressures and temperatures involved.

Oxygen may be compressed into gas cylinders by water lubricated or dry compression systems.

The amount of oxygen contained in a cylinder is determined by the pressure and temperature as referenced to a capacity chart for a specific sized cylinder. Generally, the higher the pressure, the more oxygen contained in the cylinder.

Properties

Gaseous oxygen is colorless, odorless, tasteless, and nonflammable. Oxygen supports life, readily combines with other elements, and is necessary to support combustion. Some of the properties of oxygen are:

Molecular Symbol 02
Molecular Weight 32.00
Boiling Point297.3°F (-183°C)
Freezing Point
Critical Temperature
Critical Pressure 736.5 psia (50.1 atm.)
Density, Liquid @ b.p 71.2 lbs./cu.ft.
Density, Gas, 70°F. 1 atm 0.0828 lbs./cu.ft.
Specific Gravity (Air=1) 1.1053
Specific Gravity, Liquid @ b.p 1.14
Specific Volume, 70°F. 1 atm 12.08 cu.ft./lb.
Latent Heat of Vaporization @ b.p 2932 BTU/lb.mole

Toxicity

Oxygen is non-toxic. Exposure to high purity oxygen at elevated pressures for long periods of time can adversly affect muscular coordination and the power of attention.

Number 23-C

-2-

January 10, 1963

Manufacture

The principal commercial source of oxygen is from the distillation of liquefied air. Oxygen is also produced in small amounts by the electrolysis of water.

Uses

The principal uses of oxygen stem from its strong oxidizing and life sustaining properties.

Oxygen is used in metal industries in conjunction with acetylene and othe fuel gases in metal cutting, welding, hardening, scarfing, cleaning, and dehydrating. Oxygen use is increasing in the manufacture of steel.

In the chemical and petroleum industries oxygen is used in the production of synthesis gas from coal, natural gas, or liquid fuels used to produce gasoline, methanol and ammonia, and in the OXO process for the production of aldehydes and alcohols. Oxygen is similarly used to produce acetylene by the partial oxidation of hydrocarbons. It is used in the manufacture of nitric acid by the catalytic oxidation of ammonia and in the production of ethylene and propylene oxides.

CONTAINERS

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Gaseous oxygen is shipped and stored in hollow steel containers of two general shapes—the cylinder and the tube.

The cylinder has a concave base on one end which allows the cylinder to stand upright, and is tapered to a small opening on the opposite end. The tapered or open end is threaded to receive a cylinder valve or other suitable outlet type connection. Safety relief devices are part of the cylinder valve or the outlet connections. A threaded neck ring is secured to the tapered end of the cylinder to allow a protective cylinder cap to be installed on it.

The tube is tapered on both ends that have threaded openings to which connections, valves, or safety devices are attached. Length of tubes very depending on the capacity of oxygen contained in them.

Cylinders may be used individually or in groups piped together to form portable banks or stationary storage. Tubes are generally mounted on truck-trailer chassis, railroad car beds, or stationary locations and serve as storage or use systems of large amounts of oxygen.

Number 23-C

-3-

January 10, 1963

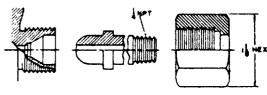
Cylinders and Tubes

Cylinders and tubes are made according to ICC-3A or ICC-3AA specifications. Cylinders and tubes are hydrostatically tested upon manufacture and every five years thereafter at 5/3 times the service pressure.

Valves

The Compressed Gas Association and the American Standards Association has adopted a thread size of 0.903 inch—14 external right hand threads per inch. It is designated as valve connection No. 540 (Fig. 1).

CGA 540 .903-14 NGO-RH-EXT.



Oxygen

Safety Devices

Fig. 1

Safety devices provide protection against excessive temperature and pressure in the container. The safety devices are part of the cylinder valves or attachments to the tubes and may take the form of frangible discs and frangible discs with fusible plugs.

Identification

Each cylinder or tube is identified between the neck ring and shoulder by:

- 1. ICC-3A or ICC-3AA, the specification controlling the manufacture of the container followed by the service pressure rating in pounds per square inch.
- 2. The serial number of the container.
- 3. The manufacturers symbol and the owners symbol.
- 4. The month and year of the container manufacture.
- 5. The month and year of subsequent five year hydrostatic retest of the container.

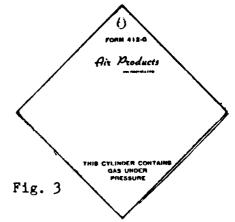
The neck ring usually is identified by the owners and manufacturers symbol.

Shipment of Oxygen Cylinders

The shipment of oxygen cylinders by public carrier must conform with Interstate Commerce Commission Regulations as set forth in Agent T. C. George's Tariff No. 13. Sections 73:401 and 73:402 describe the

labeling and identification required. The Green Label (black printing on green) is used for oxygen shipments. Figure 2 and figure 3 illustrate the front and reverse side of the shipping label.





Sizes of Cylinders

ICC Type	Dimen O.D. (In.)	Length (In.)	Water Volume (Cu.In.)	Std. Press.	(Cu.Ft.) at 10% Over- press.**
3A2015 & 3AA2015	5 7/8	32	678	55	61
3A2015 & 3AA2015	5 3/8	37	678	5 5	61
3A2015 & 3AA2015	7	23 3/4	678	55	61
3A2215 & 3AA2215	7 1/8	30	895	80	88
3A2015 & 3AA2015	7	32	985	80	88
3A2015 & 3AA2015	7	43	1337	110	122
3A2265 & 3AA2265	7	43	1337	125	138
3AA2015	7 1/4	46	1660	137	150
3AA1800	8 1/2	51	2360	175	194
3A2015 & 3AA2015	9	51	2675	220	244
3AA2265	9	51	2675	250	277
3AA2400	9 1/4	55	3025	300	330
3AA2400	10 5/8	56	4026	400	440

^{*} ICC Regulation 73.304 (d)

SAFETY CONSIDERATIONS

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The hazard associated with gaseous oxygen is fire because oxygen, although non-flammable, readily supports combustion. An explosion hazard is also to be considered where escaping fuel gas and oxygen gas may collect and mix. Cleanliness and compatibility of materials are essential in using and storing oxygen. Elimination of source of fuel or ignition from an oxygen system is an important safety consideration.

Number 23-C

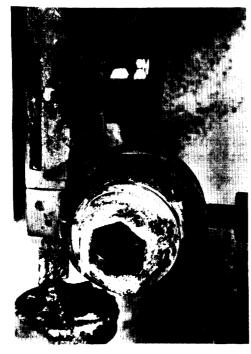
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January 10, 1963

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Figures 4 and 5 below show the damage done to regulating equipment and tubes through violation of basic safety rules governing the handling and use of oxygen and oxygen containers.



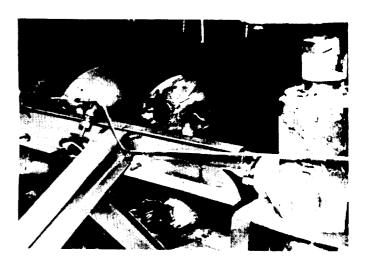


Fig. 5

Fig. 4

Buildings

- 1. Provide adequate ventilation where oxygen is being used.
- 2. Test the atmospheres in confined work areas for oxygen content.

 Material which burns in air generally burns more violently and sometimes explosively in oxygen. Oxygen in excess of 25 per cent concentration increases the hazard exposure to personnel and material.

Handling and Storage

- 1. Never drop cylinders or permit them to strike each other violently.
- 2. Cylinders should be assigned a definite area for storage. The area should be dry, cool, well-ventilated, and preferably fire-resistant. Keep cylinders protected from excessive temperature rise by storing them away from radiators or other sources of heat.
- 3. Cylinders may be stored in the open, but in such cases should be protected against extremes of weather and from the dampness of the ground to prevent rusting.

Number 23-C

-6-

January 10, 1963

- 4. The valve protection cap should be left in place until the cylinder has been secured against a wall or bench, or placed in a cylinder stand, and is ready to be used.
- 5. Avoid dragging or sliding cylinders, even for short distances. They should be moved by using a suitable hand truck.
- 6. Do not use cylinders as rollers for moving material or other equipment.
- 7. Never tamper with safety devices in valves or cylinders.
- 8. When returning empty cylinders, close the valve before shipment, leaving some positive pressure in the cylinder. Replace any valve outlet and protective caps originally shipped with the cylinder. Mark and label the cylinder EMPTY. Do not store full and empty cylinders together.
- 9. No part of a cylinder should be subjected to a temperature above 125°F. Avoid sparks or flames from welding or cutting torches or any other source coming in contact with cylinders. Do not permit cylinders to come in contact with electrical apparatus or circuits.
- 10. Never permit oil, grease, or other readily combustible substance to come in contact with oxygen cylinders or valves.
- 11. Use regulators with cylinders when connecting to circuits of lower pressure service ratings.
- 12. Smoking or open flames are prohibited in oxygen cylinder storage areas.
- 13. Know and understand the properties, uses, and safety precautions of oxygen before placing in service.
- 14. Always open an oxygen cylinder valve slowly.

Personnel Equipment

Special personnel equipment is not required. If gloves are worn, they should be clean and free from dirt and oil or grease. Safety shoes and glasses are suggested.

Fire Fighting

Since oxygen is nonflammable but readily supports combustion, fire fighting action would be to first shutoff the source of oxygen, if possible, then fight the fire according to the material involved.

- a. For wood rubbish and textile fires use water and foam.
- b. For oil, solvent, grease and paint fires use dry chemical powder, carbon dioxide, or foam.
- c. For electrical fires use carbon dioxide and dry chemical powder.

January 17, 1963 Number 24

Drain Line Explosion

Recently an underground drain line exploded at a 25 T/D liquid oxygen producing facility, scattering ground over a 35 foot area. Fortunately, no one was injured.

During a transfer of LOX from an on-site storage tank to a portable 500 gallon storage tank, an over-filling occurred. The spilled LOX was flushed down the drain with quantities of water. The buried drain from the on-site storage area empties into an open concrete ditch from the loading ramp area. Seven hours later, and after approximately 700 gallons of liquid nitrogen from a tank trailer was being disposed of in the open ditch, an explosion occurred in the drain line.

Figure 1 shows the general area of the explosion site. The arrows indicate the points where the drain line ruptured. Figure 2 is a photograph of the drain line where it joins the open cement ditch. The area around the drain line was excavated to clearly show the damage to the line.

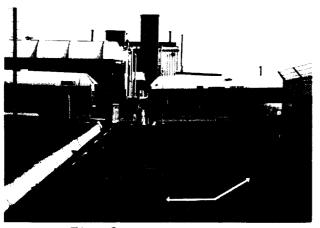


Fig. 1

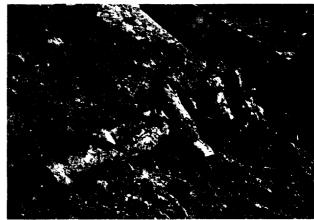


Fig. 2

The elements of this explosion, although not clearly determined by the investigation, may well be those listed below:

Oxidant An oxygen-rich atmosphere remained in the drain line after the spillage of LOX: or an ice plug formed when water was flushed down the line and trapped some oxygen.

Fuel The drain pipe joint sealer material appeared to be not compatible with oxygen: or waste material, organics, etc., which normally accumulate in drain lines.

Initiator Could have been any shock.

A few simple rules to follow to avoid accidents of this type are:

- 1. Closer supervision or training of personnel to avoid overfilling storage containers.
- 2. Never allow LOX to enter underground drain pipes because they are natural collecting spaces for unknown materials.
- 3. Use only compatible materials where drain lines may be exposed to accidental LOX spills.

March 22, 1963 Number 27

Lubricants and Thread Compounds for Oxygen Systems

The material presented below and on the following pages was extracted from the Missile Safety Officers' Special Study Kit for January-February 1963. It is intended as a guide for the selection of lubricants and thread compounds for oxygen systems, but does not supercede the materials listed in Safety Standard 609.1.

SCOPE. This article covers the use and application of lubricants and thread compounds for the installation, assembly, operation and maintenance of all oxygen systems. This article for thread compounds, covered herein, is applicable for dynamic, static, long or short term, low or high temperature and pressure conditions.

DEFINITIONS. The following definitions form part of this document:

<u>Lubricant</u> - A substance capable of reducing friction between bearing surfaces in relative motion, such as valve stems, O-rings, compressors, pumps, bolts, etc.

Antiseize - A substance capable of preventing the galling, partial welding and/or locking together of sliding metallic surfaces, such as threaded connections and fittings.

Thread Compounds - A substance which in addition to having lubricating and anti-seize properties, has sufficient consistency to fill minute voids and prevent leakage in threaded connections or fittings.

Compatibility - Compatibility, as defined by this document, refers to the tolerance of oxygen, by a substance, under operational conditions, without effecting a hazardous reaction.

GENERAL

Compatibility - The compounds listed herein are compatible with liquid or gaseous oxygen, nitrogen, helium and air and with most metallic and non-metallic materials. The main exceptions are the fluorochemicals which may be reactive with aluminum, magnesium, or titanium under impact or shear loads. For lubrication of these light metals it is recommended that only molybdenum disulfice compounds be used as lubricants and Teflon tape be used as a thread sealant. Some fluorochemical lubricants may affect buna N, nitrile, silicone rubber and polymers of chlorotrifluoroethylene. The fluorochemical lubricants do not prevent corrosion of iron and copper alloys, unless they have been properly stabilized with specific corrosion inhibitors. No filters or foreign materials should be added to the lubricants.

 $\underline{\text{Toxicity}}$ - The compounds listed herein are all nearly inert materials with little or no odor. Some toxic substances may be generated by heating fluorochemicals above 500°F.

<u>Application</u> - Much of the success of a lubricant stems from the care used in its application. The following special instructions should be observed to achieve maximum performance and avoid system contamination:

- 1. Teflon Tape Apply tape under tension three threads back from the end of male pipe thread and in the direction of the thread. Use enough tape to go around once plus an overlap of a half inch. For larger pipes overlap each turn. A small portion of the tape shall extend outside the joint for inspection purposes.
- 2. <u>Fowdery Lubricants</u> Dry powders and slurries are applied by burnishing metal surfaces. The excess material shall be wiped away before installation.
- 3. Containers All lubricants, including Teflon tape, should be packaged in individual containers with closures to keer out dust and particles, and should be clearly labeled.
- 4. <u>Quantity</u> All lubricants and sealants should be applied sparingly to the back threads of male ripe or fittings. Lubrication and antiseize principles are based on the properties of

Number 27 -2- March 22, 1963

the films of these substances; therefore, excess amounts are superfluous and wasteful. Excess material should be carefully wiped off with a clean lintless cloth or paper. Do not apply to nose of fitting or to first threads. Threads should not be filled out. Bulk use of lubricants or sealants to fill gaps and loose connections is an unsafe practice; thread sealants are not a substitute for tinning or soldering.

 $\underline{\text{Incompatible }}\underline{\text{Materials}} \text{ - Not acceptable or approved for use in oxygen and associated systems}\\ \text{are:}$

- 1. Lubricants and thread compounds covered by MIL-T-5542B and QPL 5542-6. The compounds covered by these documents are outside the scope of this list because they contain materials that are highly hazardous and reactive with oxygen, namely mixtures of graphite and Aroclor. Both of these substances have been shown to be highly hazardous and reactive with oxygen by numerous tests. These compounds were specified many years ago for use in breathing oxygen systems in accordance with the state-of-the-art at that time and are not adequate for use in current liquid oxygen systems. This includes compounds such as Dag 217, Lox Lube, Lox Safe, Reddi-Lube No. 2 and NA 2-20502B.
- 2. Lubricants and thread compounds containing any one or more of the following substances which have been found to be reactive and hazardous with liquid oxygen:
 - a. Synthetic hydraulic fluids such as:

Chlorinated biphenyl (Aroclor)
Dibasic acid esters (MIL-L-7808)
Phosphate esters (TCP, Pydraul,
Skydrol, Cellulube)
Silicate esters (OS-45, Oronite)

Silicones, Silanes (DC series of oils and greases) Polyglycol ethers (Ucon Fluids) Polyhydric Alcohol (Glycerol, ethylene glycol)

b. Carbonaceous materials such as:

Graphite

Carbon black

Asphalt

c. Hydrocarbon oils and greases containing animal, vegetable or mineral substances such as:

Linseed Oil Glycerine Lanolin Vaseline Castor Oil Petrolatum Mineral Oil Paraffin

d. Organic resins and elastomers, such as those listed below:

Polyethylene Polysulfide Nitrile Phenolic Polyvinyl Polystyrene Buna-N Polyester Ероху Polyamide Silicone Latex Urethane Nylon Isoprene Thiokol Neoprene Butylene

3. Joint sealing compounds made of polysulfide rubber and urethane or epoxy resins such as:

Pro-Seal 994 PR-1531 Chemseal 270

These compounds have been accepted officially for use in sealing floor cracks and joints in cement construction near oxygen installations. However, this measure, taken in the light of expediency, and the realization of the absolute lack of equivalent materials that are compatible with oxygen, in no way qualifies them as being completely LOX-compatible. Oxygen compatibility cannot be claimed for any elastomeric material. Therefore, those compounds which are listed above and others which are authorized in missile construction specifications as floor sealing compounds should never be allowed in oxygen systems.

4. Tricresyl Phosphate (TCP) - This compound listed in paragraph 2 a above, has a very low threshold of impact sensitivity with liquid oxygen and it is therefore unacceptable for use in any place where it will come in direct contact with oxygen in oxygen systems. However, it can be used to lubricate pumps or mechanisms used to pull or maintain a vacuum on a liquid oxygen storage vessel. The same is also true of Cellulube 220 which is a compound very similar to TCP except for a different isomer content.

Number 27

-3-

March 22, 1963

S A F E

Y - GRAA BASIS OF APPROVAL. The criteria used in developing this list were based on test data from impact testing machines developing high levels of kinetic energy and repeatability. Definite values for the qualification of new materials will be added to this article upon establishment and verification of adequate acceptance standards.

Basically the compounds listed are made up of well known near-inert materials such as fluorocarbon chemicals, molybdenum disulfide, sodium silicate, mica and water.

All the ingredients in the compounds are fully disclosed and they are all known to be safe. They do not contain resins, binders, or adhesives. The carriers and vehicles used are water, alcohol or chlorinated solvents, all of which evaporate upon application.

There is enough variety and quantity among the materials listed to fulfill any lubrication or thread sealing requirements encountered in missile oxygen systems. There are oils, greases, powders, aerosol dispersions, films, and colloidal suspensions. Among the fluorochemicals there are oils with similar viscosities as those of TCP, Aroclor, glycerine, SAE 30 motor oil and Cellulube.

APPROVED OXYGEN COMPATIBLE LUBRICANTS AND SEALANTS

Fluorinated Polymers of Chlorotrifluoroethylene:*

 Mfr. Halocarbon Products Corporation 82 Burlews Court Hackensack, New Jersey

HALOCARBON 4-11, light oil**
HALOCARBON 11-14, light oil**
HALOCARBON 11-21, medium oil**
HALOCARBON 13-21, medium oil**
HALOCARBON 13-21, medium oil**
HALOCARBON 10-25, heavy oil**
HALOCARBON 25-20, medium grease
HALOCARBON 14-25, heavy oil**
HALOCARBON 15-10, heavy grease
HALOCARBON 15-11, grease stick

STOPCOCK GREASES:

Standard Grade, Medium Grease; High Temperature Grade, Heavy Grease

FLUOROPACK, packing putty FLUOROCHEM A0369, medium oil FLUOROCHEM A0213, light oil

 Mfr. Hooker Chemical Corporation 1200 47th Street Niagara Falls, New York

> FLUOROLUBE FS-5, light oil FLUOROLUBE MO-10, medium oil FLUOROLUBE S-30, medium oil FLUOROLUBE T-80, heavy oil FLUOROLUBE HO-125, heavy oil FLUOROLUBE, LB-160, light grease FLUOROLUBE 230, light grease FLUOROLUBE MC-600, medium grease

FLUOROLUBE 1000, medium grease
FLUOROLUBE HG-1200, heavy grease
FLUOROLUBE 1500, heavy grease
FLUOROLUBE 2000, heavy grease
FLUOROLUBE GR-362, light grease (-40 to 150°F)
FLUOROLUBE GR-470, medium grease (0° to 300°F)
FLUOROLUBE GR-544, light grease (30 to 300°F)
FLUOROLUBE GR-660, medium grease (100 to 400°F)

^{*} These products contain inhibitors to minimize corrosion of iron and copper alloys.

^{**} All the oils are produced in two grades, denoted by addition of letters "L" or "E" which indicate a light or heavy (under 1 per cent) addition of an inert corrosion inhibitor. These designations replace all previous designations such as 4-11B, 4-11V; however, the quality of the materials is not affected and existing supplies should be used up first.

^{****} Greases with the designation 5A (25-10M-5A, 4-11-5A, 25-20M-5A) contain a petroleum base corrosion inhibitor which makes them impact sensitive and therefore are excluded from this list since they do not match the high degree of inertness found in the other materials listed.

Number 27

-4-

March 22; 1963

The above designations replace nomenclature but since the quality or inertness of the materials are in no way affected, stocks with older numbers should be used up first according to the following relationship:

FS-5 replaces FS S-30 replaces S HO-125 replaces HO

places 5 i

LG-160 replaces LG

T-80 replaces T-45

MG-600 replaces MG

Chlorinated Polymers of Chlorotrifluoroethylene:

 Mfr. Minnesota Mining and Manufacturing Co. 900 Bush Avenue St. Paul 6, Minn.

KEL-F No. 1, light oil

KEL-F No. 10, heavy oil

KEL-F No. 90, medium grease

KEL-F No. 3, medium oil

KEL-F No. 40, soft wax

 Mfrs: Halocarbon Products Corporation Hooker Chemical Corporation Minnesota Mining and Manufacturing Co.

FLUOROTHENE G, heavy grease

FLUOROTHENE MG, heavy grease

Fluorinated Polymers of Perfluorocyclic Ether and Perfluoro-Butylamine:

Mfr. Minnesota Mining and Manufacturing Co. 900 Bush Avenue St. Paul 6, Minn

FD-75, very light oil

FC-43, light oil

Polymers of Tetrafluoroethylene (Thread Sealants Only):

Powdered Resin Dispersions

 Mfr. Eco Engineering Co. 12 New York Ave. Newark 1, New Jersey T-FILM, aqueous dispersion, liquid

 Mfr. Hoke Incorporated 136 South Dean Street Englewood, New Jersey SLIC-SEAL, aqueous dispersion, liquid

Unsintered Resin Film

1. Mfr. Permacel New Brunswick, New Jersey RIBBONDOPE No. 412, Teflon Tape

 Mfr. Minnesota Mining and Manufacturing Co. 900 Bush Avenue St. Paul 6, Minn. PIPE THREAD SEALANT No. 48 and No. 537, Teflon Tape

Mfr. Fluoro Plastics, Inc.
 Federal Street
 Philadelphia 46, Pennsylvania

FLUORO-TAPE #26, Teflon Tape

4. Mfr. Crane Facking Company 600 Oakton Street Morton Grove, Illinois THREAD-TAPE, Teflon Tape

G R A M



Number 27

-5-

March 22, 1963

Fluorocarbon Telomer Dispersions

 Mfr. DuPont Company Organic Chemicals Department Wilmington 98, Delaware SLIPSPRAY, Chlorinated solvent dispersion, aerosol spray

2. Mfr. Drilube Corporation 723 W. Broadway Glendale, California VYDAX-AR, Chlorinated solvent dispersion, liquid

DRILUBE 842, Chlorinated solvent dispersion, aerosol spray

Colloidal Dispersions of Powdered Molybdenum Disulfide

1. Mfr. Acheson Colloids Port Huron, Michigan DAG No. 206*, alcohol dispersion, liquid DAG No. 210, aqueous dispersion, liquid

 Mfr. Drilube Corporation 723 W. Broadway Glendale, California DRILUBE 701**, alcohol dispersion, liquid OXYLUBE 702, aqueous dispersion, liquid OXYLUBE 703, aqueous dispersion, paste

 Mfr. Alpha Molykote Corporation 65 Harvard Avenue Stanford, Connecticut

MOLYKOTE Type Z, fine powder
MOLYKOTE MICROSIZE, very fine powder
MOLYKOTE SPRAY KOTE, alcohol dispersion,
aerosol spray
MOLYKOTE X-15, aqueous sodium silicate
dispersion, liquid

Colloidal Dispersions of Powdered Mica

 Mfr. Acheson Colloids Port Huron, Michigan

DAG No. 224, aqueous dispersion, paste

^{*} Requires evaporation before assembly.

^{**} Requires baking for evaporation of solvent before assembly. DRILUBE is also known as OXYLUBE 701.

August 21, 1963 Number 31

Sniff Those Cylinders Before Refilling

A number of "near misses" and "incidents" have occurred in the past year which suggest that closer attention should be given to detecting "stinkers" (cylinders containing odors, usually acetylene or other fuel gases) before cylinders and containers are refilled.

- An exygen cylinder at 2200 psig returned to the R&D laboratories for analysis under the I&M quality control program indicated 4.5 ppm acetylene. Since the source of the cylinder was from a facility obtaining its oxygen from a liquid storage system, it was suspected that the LOX storage system was contaminated. An analysis of a separate liquid sample indicated less than 0.05 ppm acetylene in the liquid oxygen storage, thereby indicating the first sample cylinder was a "stinker" that was undetected at the filling location. The original acetylene content of the "stinker" before filling is calculated to be 720 ppm, an amount which can be detected by sniff testing. The amount of acetylene in this instance presented no danger of fire or explosion because 720 ppm was about 2.8% of the lower explosive limit of an acetylene-air mixture.
- A cylinder filling plant detected a "stinker" and decided to steam clean the inside of the cylinder. Upon inserting the steam line into the cylinder and starting the flow of steam, an explosion occurred. The reaction was contained by the cylinder with no other damage excepting a mighty scared operator. Evidence of the reaction was the sound of the explosion and the warm sides of the cylinder. The cause of the reaction is believed to be a release of static electricity from the steam line which ignited an air or oxygen-fuel mixture.
- 3. An empty AP-3 liquid nitrogen cylinder was picked up from a customer and left on the truck which was driven to a garage for replacement of brake lining. The residual liquid nitrogen in the AP-3 vaporized and raised the cylinder pressure to the set pressure on the safety valve causing it to pop intermittently. A garageman, upon entering the area, experienced great difficulty in "getting his breath" and assumed a high nitrogen concentration in the air as being the reason even though a strong pungent odor prevailed. Experienced personnel later identified the odor as being that of chlorine gas. The AP-3 cylinder was returned from a customer who used chlorine in his process. Inexperienced customer personnel misoperated their process system allowing chlorine to transfill into the AP-3 cylinder. On further checking a second AP-3 cylinder was found contaminated with chlorine gas.
- Explosions were experienced on two occasions in oxygen cylinders at the same customer location where propane is being used as the fuel source for their welding and cutting operations. It is believed that propane transfilled into the almost empty oxygen cylinders during periods with the 4. Explosions were experienced on two occasions in oxygen cylinders at the

August 21, 1963 Number 31 Fage 2

supply of gases shut off at the torch valves and the cylinder valves were on as between periods of torch operation. Subsequent torch operation allowed flame to propagate back to the oxygen cylinder where reaction took place. In both cases, the cylinders contained the explosion.

5. A more recent case involving an oxygen regulator fire possibly could have been caused by transfilling the oxygen lines and regulator with acetylene. An oxygen cylinder, in use, becaue empty and required changing. The companion acetylene cylinder and regulator was allowed to remain open and the supply cut off at the torch valves only. Upon connecting the oxygen regulator, still adjusted to flow conditions, and the full oxygen cylinder valve slowly opened, the reaction occurred causing regulator burn-out and injury to the operator. Heat generated by the velocity of the oxygen flow is believed to be the initiator of this reaction.

The incidents listed above point out clearly that explosive mixtures can and do occur in cylinders while in customers' possession. The need for vigilance in careful inspection of all returned cylinders at our cylinder filling plants is mandatory. Each cylinder filling plant should:

- a. Sniff test all cylinders, including liquid cylinders, but not hydrogen cylinders or specialty gas cylinders identified with a black neck ring.
- b. Have set procedures for processing "stinkers" when found.
- c. Know the application each customer has for the cylinders. Particular attention should be paid to cylinders used in special customer processes.
- d. Wherever possible, determine the source of all "stinkers" and advise the customer concerning the receipt of "stinkers" from his location and how to avoid recurrence.
- e. Advise the customer on cylinder safety practices.

October 4, 1963 Number 35

Vacuum Pump Failures

A "Near Accident--Unsafe Practices or Conditions" report received a few days ago brings the total of vacuum pump failures to six; five failures were fire and/or explosion, and the other was oil contamination through misoperation.

A similarity exists between three failures at affiliate locations and one failure at an APCI location where fire and/or explosion damaged vacuum systems. Each failure occurred immediately or shortly after changing from evacuating nitrogen cylinders to evacuating oxygen cylinders. The causes of these failures are not known, but all of the ingredients for a reaction are present: the oxidant—oxygen enriched atmosphere; the fuel—vacuum pump lubricant, dirt, metal; the ignitor—temperature, friction.

A fifth vacuum pump failed by fire and/or explosion because lack of communication between personnel at shift change time allowed pressurization of a vacuum system to 150 psig oxygen. Upon starting of the pump, explosion and fire caused the pump housing to fracture and caused slight injury to personnel. A safety relief valve was not part of this vacuum system.

The sixth failure was one of misoperation where, due to wrong sequence of valve operation, vacuum pump lubricant back-flowed into the manifolds and oxygen cylinders. Fortunately, this contamination was discovered before further compression of oxygen took place. A solvent wash of the manifold and extensive cylinder cleaning were initiated immediately to place the system in a safe operating condition.

The following recommendations are made to avoid accidents in your cylinder evacuation system:

- 1. Comply with Safety Standard 607.2.2.5 which requires separate vacuum systems for oxygen and inert gaseous products, solenoid valves for the isolation of vacuum pumps in the event of power failure, and vacuum relief valves to prevent overpressurization of vacuum lines and equipment.
- 2. Train all personnel in the correct operation of the vacuum equipment and system.
- 3. Make certain that all cylinders to be evacuated do not contain residual pressure.
- 4. Establish an inspection and maintenance program for the safety devices that are part of the vacuum system.

SAFETY DEPARTMENT WWSchmoyer/jmf



May 8, 1964 Number 43

Pressure Gauge Failures

Two accidents have been reported recently involving high pressure gauges. Personnel injury was minimized because of partial observance of safety regulations.

In the first accident, personnel injury was avoided when a high pressure gauge failed on an oxygen manifold at a cylinder gas filling facility because the manifold gauge was located at an elevation above face height. The force of the explosion and the fire which followed vented from the gauge case harmlessly over the head of the person working at the manifold. If the gauge had not been elevated, it is quite possible that the operator would have been seriously injured.

In the second accident, a $2\frac{1}{2}$ " high pressure oxygen gauge failed while checking residual and final cylinder pressure at a cylinder filling location. The force of the explosion discharged into the face of the operator. Eye injury was avoided because the operator was wearing his safety glasses. He did receive cuts on the face and to the right hand as a result of this gauge explosion.

The cause of both gauge failures was a combustion reaction between oxygen and hydrocarbon oil in the bourdon tube. The gauge in the first incident did not conform with Design Standard 531.2, and was not completely modified to Design Standard 531.10.2 in that a restrictive orifice was not installed in the line ahead of the gauge. The gauge had not been suitably cleaned for oxygen service. The gauge in the second incident, although conforming to Design Standards, was being used to test cylinders in other product service as well as cylinders in oxygen service.

A review of all gauge applications at each production facility for compliance to standards is recommended. Here are some of the points to look for:

- 1. Compliance with Design Standard 531.2. Applicable to 4½" or larger diameter gauges placed in service after August 1961. The gauge should have:
 - a. Solid front construction
 - b. Plastic crystals
 - c. Blow-out backs
- 2. Modification of $4\frac{1}{2}$ " or larger diameter gauges placed in service prior to August 1961 to agree with Design Standard 531.10.2. The gauge should have:
 - a. Plastic crystals
 - b. Case or back blow-out plugs
 - c. Restrictive orifice at inlet to the gauge



- 3. All gauges in oxygen service are to be identified with a label on the face "Oxygen--Use No Oil" and used in no other service.
- 4. Gauges should be mounted a minimum distance of 6'4" above the floor on all cylinder charging manifolds to place the gauge above face height of the average person. This is particularly important because the bourdon tubes of high pressure gauges on manifolds are stressed through their entire range many times during a normal working day. Other applications of high pressure gauges which are exposed to strong pulsations or to many fluctuations through the entire range should be considered for elevation above face height, if it is practical to do so.
- 5. High pressure gauges which are used to check residual or final pressure in cylinders or tubes should be attached to the valve outlet in such a manner that the gauge face is in a horizontal attitude facing upward or slightly towards the vertical. In this position any force involved with a failure of the gauge will vent away from the operator and minimize the possibility of injury. The gauge dial should not be watched while pressure is being applied. Read the gauge dial only after the valve on the cylinder or tube has been opened to the gauge.

SAFETY DEPARTMENT WWSchmoyer/jmf

January 3, 1966 Number 50-C

HUMAN TORCHES

Quite a bit of publicity has been given to those persons who have turned themselves into "human torches" because of political or religious beliefs, but little attention is ever given to those people in industry who unnecessarily turn themselves into torches through accidental exposure to oxygen-enriched atmospheres.

Several such accidents have occurred in the past year which could have been prevented if more emphasis had been placed on instructing the worker concerning the hazards associated with the use of oxygen.

In one case, the equipment in a confined working area was heavily coated with dust. Prior to starting work, the worker blew the dust off of the equipment with oxygen from his torch. With the dirt removed, the worker lit his torch and immediately his oxygen-saturated clothing started to burn.

The other accident occurred in summertime. On a particularly hot day, a sweating worker inserted his torch tip inside his shirt and turned on the oxygen to cool himself. He left the oxygen flow on for some period of time. Upon resuming his work and after lighting his torch, the worker's clothing burst into flames.

Needless to say, both persons were severely burned. All this unnecessary suffering could have been avoided if the hazards involved with the gases being used in this type operation had been fully explained to the workers.

Oxygen, although nonflammable, supports combustion. An object which burns in air will burn many times more vigorously in oxygen. When these workers used oxygen to clean away dust and to cool the body, they were in effect increasing the oxygen content of the atmosphere in their work areas. This oxygen-enriched atmosphere permeated their clothing which was ignited by a hot spark from their burning operation.

SAFETY DEPARTMENT WWSchmoyer/dt

November 26, 1967 Number 60-C

OXYGEN REGULATORS IN THE WELDING INDUSTRY

During the last four years, we have investigated 20 reported accidents involving oxygen regulators to determine the cause of the accidents and a logical approach for preventing their recurrance.

The causes of the 20 accidents investigated fall into three categories as listed below:

No. of Accidents	Percentage	Cause	<u>Comments</u>
3	15%	Seat Ignition	Reaction originating in high pressure side of regulator
12	60%	Fuel Mixture	Reaction originating in low pres- sure side of regulator
5	25%	Unknown	Insufficient information available to determine cause

Failure to follow established operating practices was a contributing factor in 75 percent of the accidents investigated. Knowing the products you are working with, understanding the mechanics of reaction, and following established operating procedures are the necessary ingredients to minimize regulator accidents.

Oxygen, a colorless odorless gas, supports combustion, but only when a fuel is present and after ignition takes place.

Most materials may be considered as fuels in the presence of oxygen. We readily recognize that paper, wood, coal, oils, and greases are fuels, but we don't normally think that metals and other materials of construction are also fuels. The difference between these fuels is the temperature at which they can be ignited. The lower the ignition temperature of the material, the more easily it can be ignited. Materials selected for use in oxygen systems must be suitable for the temperature and pressure for the intended service.

Ignition sources most likely to be involved with a regulator reaction are spark and open flame, impact, friction, velocity, and heat of recompression. Spark and open flames from various sources (matches, electricity, torch lighter) are easily recognized as being capable of igniting fuel mixtures. Not so easily recognized as sources of ignition energy sufficient to ignite materials of construction are impact (objects striking against each other), friction (material in physical contact and rubbing against each other), velocity (the speed of gases or fluids flowing through lines or equipment), and recompression (the heat developed when closed areas of low pressure gases are compressed by the entering high pressure gases in a short period of time).

Since all three elements (oxygen, fuel, and ignition) are necessary for the controlled operation of the welding and cutting equipment, steps must be taken to eliminate outside ignition energy sources which are capable of causing reaction prematurely. Selection of material with high ignition temperatures in the design of oxygen equipment further reduces the possibility of reaction occurring. Some of the steps necessary to eliminate the different sources of ignition energy are listed in the following table.

Ignition Energy Source

Control

- 1. Open flame and sparks
- 1. Selection of work area. Instructions to personnel.

2. Impact

2. Filters at the inlet and the seat of the regulator. Examine supply source valve outlet making certain it is free of dust and foreign particles.

3. Friction

3. Periodic maintenance of regulator.

4. Velocity

- 4. Correct regulator and pressure settings for the job. Open supply source outlet valve slowly. Follow operating instructions.
- 5. Heat of recompression
- 5. Open supply source outlet valve slowly. Follow operating instructions.

Since regulators are a part of the system necessary for the performance of metal cutting and welding operations, the safety requirements must be known and observed for a total system which includes supply sources for oxygen and for fuel gas, regulators, hoses, and welding or cutting torches. Listed below are the safety requirements and operating instructions for such a system.

Oxygen Supply System

Oxygen, available for the welding operations, is contained in steel cylinders at pressures to 2500 pounds per square inch gauge.

- 1. Never permit oil or grease to come in contact with oxygen cylinders, valves, regulators, hoses, or fittings. Do not handle oxygen cylinders with greasy or oily hands or gloves.
- 2. Never use oxygen near flammable materials, especially grease, oil, or any substance likely to cause or accelerate fire. Oxygen itself is not flammable but does support combustion.
- 3. Do not store oxygen and acetylene cylinders together.
- 4. Always refer to oxygen by its full name--"oxygen," and not by the word "air."
- 5. Never use oxygen from a cylinder without a suitable regulator attached to the cylinder valve.
- 6. Never tamper with, or attempt to repair, oxygen cylinder valves.
- 7. Never use oxygen regulators, hose or other pieces of apparatus with any other gases, only oxygen.
- 8. Never attempt to mix any other gases in an oxygen cylinder.
- 9. Open oxygen cylinder valve slowly and completely when in use.
- 10. Be certain that the cylinder valve is tightly closed, and capped with a cylinder cap, before handling the cylinder.
- 11. High pressure cylinders should be chained to a wall, bench, cylinder cart, or other firm support when in use.

Acetylene Gas Supply System

Acetylene, the usual fuel gas used in welding systems, is contained in porous

material filled steel cylinders and dissolved in acetone at pressures to 250 psig at 70°F.

- 1. Never use acetylene at pressures in excess of 15 psi. The use of higher pressures is prohibited by insurance authorities, and by law in many localities. To adjust for increased volume requirement, use large hosenot increased pressure.
- 2. Call acetylene by its full name, "acetylene," and not by the word "gas." Acetylene is far different than city gas or furnace gas.

3. Keep sparks, flames, and heat away from acetylene cylinders.

4. Should a leak occur in an acetylene cylinder, take the cylinder out in the open air, keeping it well away from fires or open lights. Notify the manufacturer at once.

5. Turn the acetylene valve so that the valve outlet will point away from the oxygen cylinder.

6. Acetylene cylinder key, for opening the cylinder valve, must be kept on the stem while the cylinder is in use so that the valve may be quickly shut off in an emergency.

7. When opening an acetylene cylinder valve, turn the key about one full turn.

3. When returning empty cylinders, make certain that the valves are tightly closed to prevent escape of residual acetylene. Make certain the cylinder cap is in place.

9. Never use acetylene regulators, hoses, or other pieces of apparatus with

any other gases.

- 10. Never attempt to transfer acetylene from one cylinder to another, nor to refill an acetylene cylinder. Never attempt to mix any other gas, or gases, in an acetylene cylinder.
- 11. Never use acetylene from cylinders without reducing the pressure through a suitable regulator attached to the cylinder valve.

12. Acetylene cylinders should be used and stored in an upright position.

13. The use rate in cubic feet per hour of acetylene from cylinders should not exceed 1/7 of the cylinder's capacity; for example, 42 cubic feet per hour out of a 300 cubic foot cylinder.

Regulators

The instructions below for using regulators pertain especially to oxygen regulators. The same consideration should be given to regulators in other services. Regulators with the exception of special applications, are provided with a means of adjusting the delivery or use pressure. The adjusting knob or screw is the name given to the pressure adjusting mechanism. It is usually found on the front of the regulator. When the adjusting screw is turned clockwise, it places tension on the spring system of the regulator and "opens" the regulator valve against the gas pressure for service at the pressure set by the adjustment. When the adjusting screw is turned to its furtherest counterclockwise position, the tension is released on the spring system and "closes" the regulator valve.

A. Attaching the Regulator

- 1. Examine the cylinder valve and its outlet for oil, grease, mud, or other dirt. Wipe off any dirt with a clean cloth. Use chlorinated solvents to remove oils and greases.
- 2. Crack open the cylinder valve for an instant to blow out any dirt which may have accumulated in the valve outlet. This applies to the oxygen cylinder only.

- 3. Examine and make certain the inlet connection on the regulator is clean.
- 4. Make certain the regulator is closed.
- 5. Carefully attach the regulator to the cylinder and turn the regulator inlet nut hand-tight. Then tighten the inlet nut with a wrench.
- 6. Attach the proper size hose to the regulator outlet fitting.
- 7. The operator should position himself on the side of the cylinder opposite the outlet of the cylinder valve, place his hand on the valve (in such a manner as not to be in contact with or have the arm pass over, in front of, or behind the regulator), and slowly open the cylinder valve.
- 8. Hold the thumb over the hose outlet fitting and adjust (open) the required ulator to one (1) psi. By alternately releasing and replacing the thumb, blow out any dirt which may have accumulated in the hose. Close the regulator.
- 9. Attach the desired equipment--welding or cutting torch, and close the torch valves.

B. Operating the Regulator

After the above steps have been completed --

- 1. Adjust (open) the oxygen and fuel gas regulators to the predetermined pressure required by the work to be performed. Never stand directly in front of the regulators while making any adjustment.
- 2. To check the regulator adjustment and to purge the oxygen regulator,
 (1) open the oxygen torch valve, observe the regulator adjusted pressure,
 readjust if necessary, and (2) close the oxygen torch valve.
- 3. Perform the above steps with the acetylene or fuel gas to check the regulator adjustment and to purge any oxygen or air from the fuel gas system.
- 4. Open the acetylene torch valve and light the acetylene with a spark producing type lighter.
- 5. Open the oxygen torch valve gradually and adjust the flame to meet the requirements of the work to be performed.
- 6. When the torch operation has been completed, first close the acetylene torch valve and then the oxygen torch valve.

C. Operating Conditions

- 1. If the torch is to be used intermittantly at short regular intervals, it is not necessary to perform any other steps prior to relighting the torch, excepting to observe if the regulated pressure is as previously adjusted.
- 2. If the torch and equipment is to be out of service for extended periods perform the following:
 - a. Close the oxygen and fuel gas cylinder valves.
 - b. Open the acetylene fuel gas torch valve and <u>close</u> the acetylene or fuel gas regulator to bleed the pressure from the fuel gas side of the equipment. Close the fuel gas torch valve.
 - c. Open the oxygen torch valve and <u>close</u> the oxygen regulator to bleed the pressure from the oxygen side of the equipment. Close the oxygen torch valve.
- 3. Repeat all the steps in Paragraph B, Operating the Regulator, when placing the equipment back into service after long periods of disuse.

D. Removing the Regulator From Service

1. Stop torch operations by closing the acetylene or fuel gas torch valve and the oxygen torch valve in sequence.

2. Close the oxygen and fuel gas cylinder valves.

- 3. Open the acetylene or fuel gas torch valve and close the acetylene or fuel gas regulator to bleed the pressure from the fuel gas side of the equipment. Close the fuel gas torch valve.
- 4. Open the exygen torch valve and close the exygen regulator to bleed the pressure from the exygen side of the equipment. Close the exygen torch valve.
- 5. Disconnect the equipment from hose and the hose from the regulator.

6. Remove the regulator from the cylinder.

7. Replace the protective cap over the cylinder valve.

E. Changing Cylinders

1. When it is necessary to change either the oxygen or fuel gas supply cylinder because one of them becomes empty, follow the steps in Paragraph D. Removing the Regulator From Service, excepting Step 5.

2. Replace the empty cylinder.

3. Repeat all the steps in Paragraph A, Attaching the Regulator, excepting step 8 and follow with the steps in Paragraph B, Operating the Regulator.

F. Maintenance of Regulator

- 1. Regulators when not connected to cylinders should be stored in places where oil, grease, and dirt may not collect on them.
- 2. Regulators which are used continuously should, at regular intervals, be returned to the manufacturer or an authroized representative for complete disassembly and replacement of worn parts as a preventive maintenance program.

3. Some indications of faulty regulators are:

- a. The regulated pressure gradually creeps to a higher value without changing the adjusted pressure setting. This is an indication of a bad valve seat or stem.
- b. Pressure gauges do not register correctly. Dirt may be in the gauge passages.
- c. Regulated pressure drops noticeably when the torch equipment is lighted. Inlet and seat filters may be partially blocked or the diaphragm may be weakened.
- d. When the cylinder valve is closed and without closing the regulator, the pressure on the gauges drops to zero pressure. The regulator or connected equipment has developed leaks.
- 4. Faulty equipment should be repaired immediately by the manufacturer or an authroized representative.
- 5. Inspect the hoses frequently for cracks, worn areas, and oils, greases, and dirt, and replace as necessary.

VAPORIZER

CRYOGENIC LIQUID DISPOSAL

PURPOSE

This standard establishes the preferred method and design for disposal of cryogenic liquids held-up in columns, condensers, etc. in the event of excessive contamination and to expedite plant defrost operations.

2. SCOPE

This standard pertains to all air separation plants, except the military plants producing one ton per day or less of liquid oxygen.

3. METHOD AND DESIGN

All future air plants producing cryogenic liquids, except military plants producing one ton per day or less of O_2 , shall be provided with one of the two liquid disposal vaporizers as presented below. In cases where a vaporizer cannot be used due to lack of steam or water, a drain tank may be used when the design and location of the tank is approved by the Safety Department.

The vaporizer designs presented below may also be used during periods of acetylene or hydrocarbon concentration in reboiler-condensers.

A. Vaporizer, Steam

A detailed Air Products, Inc. drawing (66587E) has been prepared for a vaporizer which can be used on tonnage oxygen plants to dispose of liquid oxygen as it gravity flows from the low pressure column and reboiler during defrost. Crude oxygen in the high pressure circuit may be drained to the defrost stack or transferred to the low pressure column.

Following are the basic criteria for this particular vaporizer.

In order to keep pressure drop down to the 5 spi, it is necessary to vent the oxygen as a cold gas, and therefore the vent from the vaporizer must be run vertically sufficient distance to prevent fogging and concentration of oxygen at ground level. The minimum elevation of the stack outlet is 50 feet above ground level, but the outlet must always be at least six (6) feet above roof eaves or the top of cold boxes. It is not necessary to locate this vaporizer remote from the operating area, providing the vent is suitably located.

VAPORIZER

CRYOGENIC LIQUID DISPOSAL

3. METHOD AND DESIGN (Contd)

A. Vaporizer, Steam (Contd)

Although this vaporizer was sized for draining a 150 T/D plant in 2 hours, using it on other size plants will merely change the draining time by a ratio of the plant size. Since the draining is intermittent, one vaporizer can be used for multiple plant installations.

A flow diagram showing application of this vaporizer is shown as Figure 1.

B. Vaporizer, Water

Basic criteria for building water exchangers for vaporizing liquid oxygen from standard plants up to and including the E-12,000 size are given on Figure 2 and Table 1. The exchanger consists of a copper coil immersed in a bath of water with a small water flow. A fan blowing over the same coil could be used as an alternate to using water.

The vaporizer may be located near the cold box, but the vent should be run to a safe location outside the building. One vaporizer can be used for multiple plant installations.

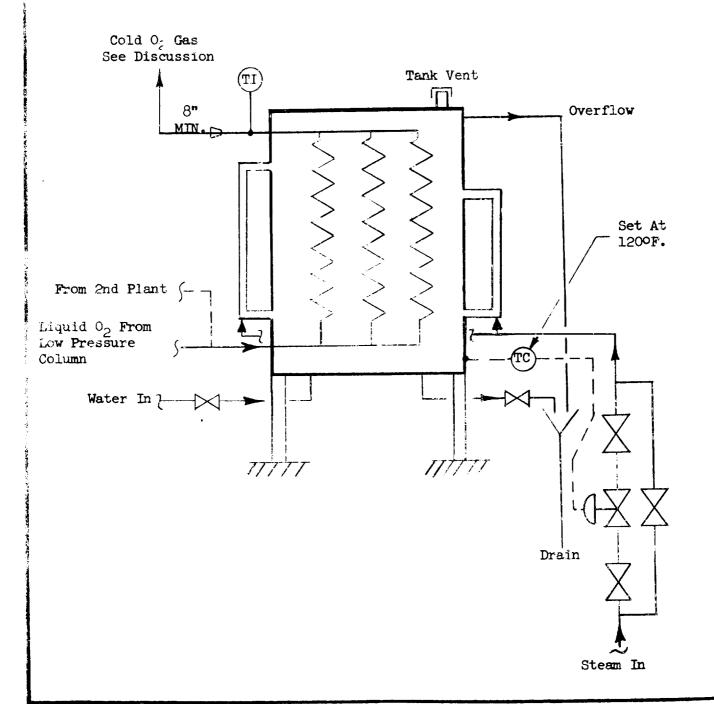
Water vaporizers for larger plants can be designed by scaling up the tube area using 50 ft. lengths.

VAPORIZER

CRYOGENIC LIQUID DISPOSAL

4. FLOW DIAGRAMS

FIGURE 1
CRYOGENIC LIQUID VAPORIZER
USING STEAM



VAPORIZER

CRYOGENIC LIQUID DISPOSAL

5. FLOW DIAGRAM (Contd)

FIGURE 2 CRYOGENIC LIQUID VAPORIZER USING WATER OR AIR

Oxygen From
Low Pressure Column

To Outside of Building

Overflow to Drain

Water Inlet

STORAGE CYLINDER

GASEOUS OXYGEN:

24 INCH O.D., 1000 P\$IG AWP

1. PURPOSE

A. This standard will provide the design requirements for gaseous storage cylinders.

2. SCOPE

This standard is for gaseous storage cylinders of 24 inch in outside diameter and a maximum working pressure that doesn't exceed 1000 PSIG.

3. DESIGN

- A. The storage cylinder shall be fabricated in accordance with Section VIII of the A.S.M.E. Code for unfired pressure vessels, latest revision and all applicable addendum.
- B. Compliance with state and local codes shall also be required.
- C. The maximum allowable working pressure shall be calculated on a minimum wall thickness remaining after deductions for manufacturing tolerances and applicable corresion factors.
- D. The cylinder shall be fabricated with a 2 inch internal National tapered pipe thread at each end in compliance with the American Standard for Pipe Threads, A.S.A. B2.1.
- E. The exterior of the forged ends small be blast cleaned.
- F. Design calculations and drawings shall be submitted to Air Products, Incorporated, for review and approval before proceeding with fabrication.

4. CLEANING

- A. Before hydrostatic test and after visual inspection the cylinder shall be subjected to the following procedure:
 - (1) Place vessel in inclined position of about he per foot to drain vessel for cleaning operation.
 - (2) Application by spray to the interior of the cylinder a solution of Oakite #77 mixed 4 cunces to the gallon of clean water. The solution shall be maintained at a temperature of 180° to 200°F during application.

The rate of spray shall be 15 lineal feet per minute at 60 PSTG pressure.

The solution may be collected for reuse provided precentage of mix and temperature is maintained.

* See Note at end of this section

GASEOUS OXYGEN

24 INCH O.D., 1000 PSIG AWP

ADDEOUG ONIGEN 24 INCH O.D., 1000 IDIO AM

: STORAGE CYLINDER

4. CLEANING (CONTD)

- (3) Spray rinse using clean room temperature water.
- (4) Descale by spray application using a 25% solution by volume of Oakite #32 (inhibited muriatic acid) maintained at a temperature of 120° to 130°F maximum at 60 PSIG pressure.

For normal rust and scale the spray rate shall be 3 lineal feet per minute

Under no circumstances shall the spray rate be greater than 15 lineal feet per minute. This solution may be collected for reuse provided percentage of mix and temperature is maintained. Acid resisting tanks, pumps, hose and other associated equipment must be used for this solution.

Safety precautions must be exercised in the handling of this solution to prevent body tissue damage.

- (5) Spray rinse using clean room temperature water.
- (6) Neutralize by application of solution as outlined in step #2 of this cleaning solution.
- (7) Spray rinse using clean room temperature water.

A direct reading titrator should be used to periodically check the solution strength.

NOTE: Safety precautions consisting of clean water eyewash and soap and water wash to body tissues should be exercised for steps #2 and #4 of this procedure.

5. TESTING

- A. The cylinder shall be free of scale and loose particles of rust.
- B. The cylinder shall be hydrostatically tested with clean uncontaminated water in compliance with the procedures specified by the applicable codes.
- C. The cylinder shall be elevated at one end to a height capable of releasing any and all trapped air.
- D. The cylinder shall then be purged with clean live steam for a period of time sufficient to evaporate all internal moisture after drainage.
- E. The cylinder shall then be plugged, airtight, with solid forged steel plugs.

GASEOUS OXYGEN

24 INCH O.D.

1000 PSIG AWP

STORAGE CYLINDER

6. PAINTING

A. The exterior of the cylinders shall be cleaned of rust and scale, by wirebrushing.

NOTE: Grinding or gouging to facilitate exterior cleaning after testing shall not be permitted.

B. The exterior only shall be painted with one coat of rubber type cylinder primer, Electric Paint and Varnish Company, Elpaco #34-451 or equal.

7. REQUISITION

- A. The requisition should include the following specific applicable data in addition to the specified requirements outlined above.
 - (1) Overall length including acceptable tolerance.
 - (2) Desired allowable working pressure.
 - (3) Estimated water volume.
 - (4) Estimated weight empty.
 - (5) Number of copies of cylinder rubbings.
 - (6) Number of copies of material certifications and A.S.M.E. Test Reports required.
 - (7) Block of serial numbers to be stamped on cylinders. If not available at date of requisition, vendor should be so advised, that same will be forth coming at a later date.
 - (8) Details of inspection by Air Products, Incorporated.

January 31, 1967

No. 54-C

Liquid Oxygen

GENERAL

Oxygen very readily supports combustion and will react with almost all organic materials and metals. Materials which burn easily in air usually burn more violently in oxygen. Equipment used in oxygen service, therefore, must be designed to utilize materials that have ignition temperatures sufficiently high and that they will not react with oxygen under the service conditions of the contemplated system.

Vessels and piping used in oxygen service should be designed to ASME Code for the pressures and temperatures involved.

Oxygen is often stored as a liquid although used chiefly as a gas. Liquid storage is less bulky and less costly than equivalent capacity high pressure gaseous storage. Liquid oxygen storage systems are insulated or vacuum insulated to minimize product losses through vaporization.

Properties

Liquid oxygen is pale blue in color, extremely cold, and nonflammable. Oxygen supports life, readily combines with other elements, and is necessary to support combustion. Some of the properties of oxygen are:

Molecular Symbol	0 ₂	
Molecular Weight	32.00	
Boiling Point @ 1 atm		
Freezing Point @ l atm)
Critical Temperature		
Critical Pressure		
Density, Liquid @ b.p		
Density, Gas, 70°F 1 atm	0.0828 lbs./cu.ft.	
Specific Gravity (Air = 1)	1.1053	
Specific Gravity, Liquid @ b.p	1.14	
Specific Volume, 70°F. 1 atm		
Latent Heat of Vaporization @ b.p		
Expansion Ratio, Liquid to Gas, b.p.		

Toxicity

Oxygen is non-toxic. Exposure to high purity oxygen at elevated pressures for long periods of time can adversly affect muscular co-ordination and the power of attention.

Manufacture

The principal commercial source of oxygen is from the distillation of liquefied air.

Uses

The principal uses of oxygen stem from its strong oxidizing and life sustaining properties. Liquid oxygen is vaporized into the gaseous state, the form in which it is chiefly used.

Oxygen is used in metal industries in conjunction with acetylene and other fuel gases in metal cutting, welding, hardening, scarfing, cleaning, and dehydrating. Oxygen is used extensively in the manufacture of steel.

In the chemical and petroleum industries, oxygen is used in the production of synthesis gas from coal, natural gas, or liquid fuels used to produce gasoline, methanol and ammonia, and in the CXO process for the production of aldehydes and alcohols. Oxygen is similarly used to produce acetylene by the partial oxidation of hydrocarbons. It is used in the manufacture of nitric acid by the catalytic oxidation of ammonia and in the production of ethylene and propylene oxides.

Liquid oxygen is used as the oxidant for liquid fuels in the propellant systems of missiles and rockets.

CONTAINERS

Liquid oxygen is stored, shipped, and handled in several types of containers, depending upon the quantity required by the user. The types of containers in use are the dewar, the cylinder, and the tank. Storage quantities vary from liters to many thousands of gallons. Since heat leak is always present, vaporization takes place continuously. Rates of vaporization may be as low as 0.4% and as high as 3% of container volume per day, depending upon the design of the container and the volume of the stored product.

Dewars

Figure No. 1 is an illustration of a typical vacuum jacketed dewar. A dust cap over the outlet of the neck tube prevents atmospheric moisture from plugging the neck tube. This type of container is considered a non-pressurized container. The unit measure of capacity of the dewar is the liter. Five to two hundred liter dewars are available. Product may be removed by pouring from the smaller containers. Product should be removed from the 50 liter and larger capacity dewars by means of pressurization and a transfer tube.

Cylinders

Figure No. 2 illustrates a typical liquid cylinder mounted on a cylinder cart for convenience in handling. The cylinder is a pressurized container which is insulated or vacuum insulated to minimize product vaporization. Safety relief valves and rupture discs protect the cylinders from pressure build-up. Since these cylinders operate at pressures up to 250 psig, their design must comply with ICC specifications. Capacity of the cylinders vary between 90 liters and 110 liters. Depending upon the design of the cylinder, product may be withdrawn as a gas by passing liquid through a vaporizing coil, or as a liquid under its own vapor pressure. Product may be withdrawn either as a liquid or as vapor on some liquid cylinders.





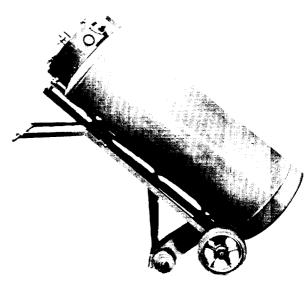
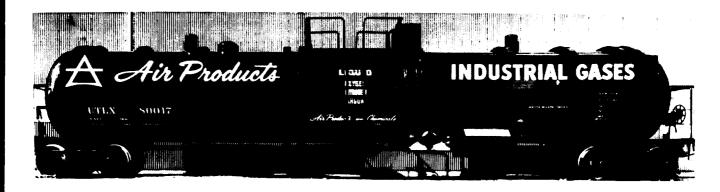


Fig. 2

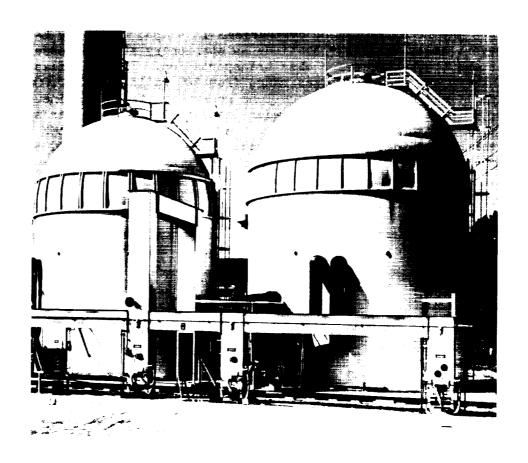
Tanks

Tanks may be spherical or cylindrical in shape. They may be mounted horizontally or vertically in fixed locations as stationary storage vessels, or on railroad car and truck chasis for easy transportation. The unit measure of capacity of tanks is the gallon. Sizes range from 500 gallons to 420,000 gallons. Tanks with capacities to about 10,000 gallons generally are vacuum insulated. Tanks above 10,000 gallons are usually powder insulated in the annular space. Safety relief valves and rupture discs protect the tanks designed to ASME specifications for the pressure and temperatures involved. Figures No. 3, 4, and 5, represent different applications of tanks.





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January 31, 1967 No. 54-C Page 5

Filling and Transfer Lines

A liquid transfer line is used to remove liquid product from dewars which cannot be conveniently handled manually. Product is removed by using product vapor pressure build-up in the dewar or by an external pressure source.

Liquid cylinders designed to deliver gas products are provided with standard Compressed Gas Association outlets so that suitable pressure regulating equipment may be attached. Similar outlets are provided for liquid product removal from cylinders through insulated or uninsulated flexible or rigid lines.

Insulated flexible or rigid lines are used to withdraw liquid product from storage tanks. Short lines for high product flows are not normally insulated. Product is pumped from storage or withdrawn by pressurization of the tank. Connections on the lines and tanks vary with the manufacturer.

Shipment of Liquid

Refer to the current Interstate Commerce Commission Regulations and the Official Air Transport Restricted Articles Tariff for information concerning the labeling, quantity limitations, container specifications, and exceptions of liquid oxygen shipments by surface and air transportation.

SAFETY CONSIDERATIONS

The hazards associated with liquid oxygen are exposure to cold temperatures, which can cause severe skin burns, overpressurization due to expansion of small amounts of liquid vaporizing into large volumes of gas in inadequately vented equipment, and the possibility of a combustion reaction if the oxygen is permitted to contact a non-compatible material.

Buildings

- 1. Provide adequate ventilation.
- 2. Keep work areas clear of combustible materials.
- 3. Post the work area with signs indicating the hazard.
- 4. Test the atmospheres in confined work areas for oxygen content.

 Material which burns in air generally burns more violently and sometimes explosively in oxygen. Oxygen in excess of 25 percent concentration increases the hazard exposure to personnel and material.

Handling and Storage

Oxygen equipment includes dewars, liquid cylinders, transfer lines, process equipment, and accessories needed to handle the product. Special considerations apply to large storage tanks because of the nature of installation.

- 1. Dewars and cylinders, when not in use or connected to a closed system, should be stored in a well ventilated storage area.
- 2. Where outside storage areas are used, provide protection for dewars and cylinders against extremes of weather.
- 3. Dewars and cylinders of oxygen should be separated from fuel gas containers and other flammable material in storage areas.
- 4. Post the work and storage areas with "no smoking, no open flame, etc." signs.

January 31, 1967 No. 54-C Page 6 Revised 1/31/68

- 5. Transfer liquid from large capacity dewars and cylinders by using product vapor pressure or external gaseous product pressure. Use pressure reducing valves if pressure source is high pressure oxygen gas.
- 6. Keep the dust caps on dewar fill-drain outlets, when the dewar is not being used, to prevent contamination. Check the caps regularly to make certain they have not become sealed by frost accumulating on the cold surface.
- 7. Provide a safety relief valve on any part of the system where liquid can be trapped between closed valves in lines or vessels.
- 3. Large capacity dewars or cylinders should be moved by two men if other mechanical handling equipment is not available.
- 9. Make certain all equipment is thoroughly cleaned before permitting liquid oxygen to enter any system.

Personnel Protection

- 1. Personnel must be thoroughly familiar with the properties and safety considerations before being allowed to handle liquid oxygen.
- 2. Chemical goggles, face shields, and loose fitting gloves of impermeable material should be used when handling liquid oxygen.

Fire Fighting

Since oxygen is nonflammable, but readily supports combustion, fire fighting action would be to first shut the source of oxygen, if possible; then fight the fire according to the material involved.

Quantities of water should be used in case of large spills of liquid oxygen to hasten vaporization and reduce the possibility of fire.

Bibliography

Air Products and Chemicals, Inc., Technical Data Manual Interstate Commerce Commission Regulations Air Transport Restricted Articles Tariff N. F. P. A. 566 Bulk Oxygen Systems and Consumer Sites

SAFETY DEPARTMENT WWSchmoyer/jg

VESSEL DESIGN BASIS

GENERAL STANDARDS

1. PURPOSE

To provide standardized minimum requirements for the mechanical design of unfired pressure vessels.

2. SCOPE

This standard encompasses the minimum design requirements of all pressure vessels designed by Air Products and Chemicals, Inc.

3. PRESSURE VESSEL TYPES

The following data has been established as an aid in differentiating between the four basic types of Air Products and Chemicals, Inc. vessel designs.

A. APCI Vessels (Non-Code)

(1) Application

All vessels 15 psig or below and vessels on certain government and export contracts regardless of pressure. *

(2) Requirements

Use ASME Gode information for design and fabrication details only. Includes use of:

- a. Design Formulas or published and accepted alternates.
- b. Gode asseptable materials and Air Products and Chemicals, Inc. approved alternates.
- Code asseptable details or other alternates based on experience.
- d. Competent welders.
- e. Inspection and tests by Air Products and Chemicals, Inc.

B. Full ASME Code

(1) Application

All vessels of design pressure over 15 psig not exempted by Paragraph U-ld and U-lg of Section VIII of the ASME Code.

* Consult Process Equipment Design Supervisor to determine where applicable.

APCI DOCUMENT

VESSEL DESIGN BASIS

GENERAL EMANDARDS

3. PRESSURE VESSEL TYPES (Cont'd)

- B. Full ASME Code (Cont'd)
 - (2) Requirements

Meet all requirements of Section VIII of the ASME Code with inspection and stamping by a commissioned inspector. Includes use of:

- a. Design Formulas or published and accepted alternates.
- b. Code acceptance materials.
- c. Code acceptable fabrication details.
- d. Code Welders
- e. Inspection and test by APCI using ASME procedures.
- f. NB stamping and test inspection by NB inspectors.

C. UM Code

(1) Application

All vessels over 15 psig exempted from inspection by a qualified inspector.

(2) Requirements

Meets all requirements of Section VIII of the ASME Code except stamped with U4 symbol. Includes use of:

- a. Design Formulas or published and accepted alternates.
- b. Code acceptable materials.
- c. Code acceptable fabrication details.
- d. Code Welders
- e. Inspection by APCI using ASME procedures.
- f. UM stamp and tests



Page 3

VESSEL DESIGN BASIS

GENERAL STANDARDS

3. PRESSURE VESSEL TYPES (Cont'd)

- D. Code Equivalent
 - (1) Application

All vessels over 15 psig exempted by Paragraph U-ld of Section VIII of the ASME Code.

(2) Requirements

Meets basic design and fabrication requirements of a full code vessel but omits inspection and stamping. Includes use of:

- a. Design Formulas or published and accepted alternates.
- b. Code acceptable materials.
- c. Code fabrication details.
- d. Code Welders.
- e. Inspection and tests by APCI using ASME procedures.

4. DESIGN PRESSURE

- A. The maximum operating pressure is the greater of:
 - (1) The highest pressure enticipated during normal operating conditions.
 - (2) The maximum precause possible at other than the normal operating consitions.
- B. The Design Pressure for vessels with an internal pressure shall be based on the following chart which determines the allowance required above the maximum operating pressure as indicated on the process specifications for the particular vessel.

510 PRESERVED BUSS

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4. DESIGN PRESSURE (Cont'd)

MAXIEUM OPERATING PRESSURE	DESIGN PRESSURE
O to 15 psig	15 psig
16 to 150 psig	Maximum operating pressure plus 5 psi or 10% whichever is greater.
151 to 300 psig	Maximum operating pressure plus 15 psi.
301 psig and higher	Maximum operating pressure plus 5%.

C. The design pressure shall be 15 psi external pressure for all vessels operating under any vacuum pressure, except those vessels specifically exempt by other sections of these standards.

5. DESIGN TEMPERATURE

A. The design temperatures shall be the minimum and maximum as listed in Tables UCS-23, USC-27, UNF-23 and UHA-23 of the ASME Code, Section VIII for the material specified. These figures must encompass the operating temperature range as listed in the design specification by the Process Department. On non-ferrous and stainless steel vessels, the minimum design temperature shall be -325°F if the lowest operating temperature is anywhere between this figure and -20°F. In the event the lowest operating temperature is below -325°F, use the actual process figure; if above -20°F use -20°F.

6. THIRMLING ALLOWANCE

- A. A corrosion allowance of the smaller of one-sixth of the calculated plate thickness or 1/16 inch shall be made for all carbon steel or low-alloy steel vessels containing air, steam or water. No corrosion allowance is required on vessels which have been designed in accordance with Paragraph UW12(c).
- B. For vessels constructed of material other than carbon or low-alloy steel, no corrosion allowance is required.
- C. Prosion and mechanical abrasion allowances are normally required only on Centrifugal Separator types of vessels.

VESSEL FEGURE, BASIG

GENERAL STANDARDS

7. MATERIAL STRESS VALUES

- A. The stress value used in design calculations shall be as allowed for the material at the applicable temperature in the Stress Value Tables of Section VIII of ASME Code.
- B. For vessels designed for external pressure, the maximum allowable compressive stress to be used in the design of cylindrical shells shall be the smaller of either the maximum allowable tensile stress or the value of the factor B determined for shells or heads subjected to external pressure. See Paragraph UG-28, Section VIII, ASME Code.
- C. Basic allowable stress values must be reduced to allow for:
 - (1) Welded joint efficiency.
 - (2) Ligament efficiency.

8. THERMAL STRESS RELIEVING

- A. All vessels or parts of vessels shall be thermally stress relieved when required by Section VIII of the ASME Code unless otherwise specified.
- B. Stress relieving is not required for vessels constructed of non-ferrous material or austenitic stainless steel in our normal applications.
- C. All thermal stress relieving shall be in full accordance with the requirements of Section VIII of the ASME Code unless specified otherwise.

9. RADIOGRAPHING

A. Full or spot radiographing, in accordance with the requirements of Section VIII of the ASME Code, shall be specified and controlled by the economics and fabrication considerations involved, and by other considerations of Paragraph UW-11.

10. WELD JOINT EFFICIENCY

A. The weld joint efficiency used in design calculations shall be as allowed in Table UW-12 Section VIII of the ASME Code for the applicable type of weld joint.

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VESSEL DESIGN BASIS

GENERAL STANDARDS

10. WELD JOINT EFFICIENCY (Cont'd)

- B. All welded joints in shell and heads shall be double welded butt type where physically possible to accomplish. Where it is impossible to weld from one side, single welded butt joints with a backing strip will be acceptable.
- C. If electrodes are used to deposit weld metal of dissimilar physical characteristics than that of the base material, the lower allowable stress must be considered in the calculations.

11. VESSEL DIMENSIONS

- A. The Process or Project Departments will normally indicate the vessel dimensions that control because of process or installation requirements.
- B. When the vessel dimensions are not indicated, they shall be as dictated by good economic and fabrication practices. For example: Vessels using torispherical heads shall use the outside diameter as the basic dimension. Vessel with ellipsoidal heads shall be based on inside diameter dimensions.

12. STRESS LOADINGS

- A. The vessel calculations shall include all stresses imposed by the following as they apply collectively or separately.
 - (1) Internal or External Pressure
 - (2) Static Weight
 - (3) Internals
 - (4) Internal Fills
 - (5) Wind and Seismic Loadings
 - (6) Support Legs or Lugs
 - (7) Lifting Lugs
 - (8) Pipe Line Reactions
 - (9) G. Loadings
 - (10) Other imposed stresses



MATERIALS OF CONSTRUCTION

1. PURPOSE

This standard extablishes the preferred materials of construction for use in Pressure Vessel Design. Every effort must be made to incorporate these materials exclusively in the design. Exceptions can be made only with the approval of the Process Equipment Design Supervisor and the Standards Department.

2. SCOPE

This standard of material of construction is for the design of Pressure Vessels by Air Products and Chemicals, Inc.

3. MATERIALS LIST

The following list of "Materials of Construction for Pressure Vessels" is cross referenced with the "Material Code Number" and "Remarks" columns.

The Material Code Number Column identifies the general category numbers. The specific size of material in that category will be selected from the Raw Material Catalog "l".

The "Remarks" column aids in selecting the material for a specific purpose and provides additional pertinent data.

4. GENERAL

- A. Pipe sizes (IPS) of 1 1/4", 3 1/2", and 7" shall not be used.
- B. The use of pipe size (IPS) of 5" shall be limited to special cases and its use must be approved by the Pressure Vessel Supervisor.
- C. Pipe size (IPS) of 2" and smaller shall be socket weld.

Page	2				10 PRESSU		ESSE		
E VESSELS	REMARKS		Not Code - Non pressure parts only.		Not Code - Non pressure parts only.	Not Code - Non pressure parts only.		Not Code - Non pressure parts only.	
MATERIALS OF CONSTRUCTION FOR PRESSURE VESSELS	DESCRIPTION	BAR FLAT	BAR FLAT AL SB221, 5083-H112 BAR FLAT AL SB221, 6061-T6 BAR FLAT CU LT CR DHP SB152 BAR FLAT CU-SI SB98,A BAR FLAT STL HR SA306,55 BAR FLAT STL HR A107, 1020 BAR FLAT STEL SA240,304	BAR ROUND	BAR RD AL SB221, 5083-0 BAR RD CU LT CR DHP SB12 BAR RD CU-SI SB98,A BAR RD STL HR ALO7,1020	5 2	BAR STRIP	BAR STRIP AL SB211, 6061-T6 BAR STRIP AL SB211, 5083-B12 BAR STRIP CU-SI SB96,A BAR STRIP CU SOFT ANNLD DHP SB152 BAR STRIP CU LT CR SB152 BAR STRIP STL HR A425 BAR STRIP STCL HR A425 BAR STRIP STSTL SA240,304 HR P & A	
	MATERIAL CODE NO.		1-076-01-XXXX 1-074-01-XXXX 1-081-13-XXXX 1-084-15-XXXX 1-060-67-XXXX 1-061-67-XXXX 1-068-69-XXXX		1-180-01-XXXX 1-187-13-XXXX 1-191-15-XXXX 1-143-67-XXXX	1-168-69-XXXX		1-288-01-XXXX 1-290-01-14XX 1-289-01-14XX 1-300-15-XXXX 1-296-13-09XX 1-278-67-XXXX 1-284-69-14XX	

510 PRESSURE VESSELS												Page
PRESSURE VESSELS	REMARKS		Sch 40 (Std) & Sch 80 (X-Hvy) 1/8" thru 12" Sch 40 (Std) & Sch 80 (X-Hvy) SMLS Under 1" Sch 40 (Std) & Sch 80 (X-Hvy) SMLS 1" & Over	Headers - Std. Wt. X-Hvy and XX-Hvy Std. Wt. X-Hvy Headers - Std. Wt. X-Hvy and XX-Hvy	All Carbon Steel Nozzles & Caustic Solution Piping (Under 1 1/2") All Carbon Steel Nozzles & Caustic	Solution Piping (11/2" Schedules E Code Case 1308		For All Parts That Are Formed To Any Radius For Anything Formed Or Welded	Shell Material	Max. Thickness 2", Minimum Thickness 3/16".	Max. Thickness 2", Minimum Thickness 3/16".	
MATERIALS OF CONSTRUCTION FOR PRESSURE VESSELS	DESCRIPTION	PIPE - SEAMLESS	PIPE SMLS AL SB24,1 6061-T6 PIPE SMLS AL SB24,1 3003-H18 PIPE SMLS AL SB24,1 3003-H112 PIPE SMLS AL SB24,1 5083-0	PIPE SMLS CU SB42 PIPE SMLS CU-SI SB315-A PIPE SMLS RED BRS SB43	PIPE SMLS STL SA106-B	PIPE SMLS STSTL SA312 TP 304 PIPE SMLS 9% NICKEL	PLATE.	PLATE AL SB209 5083-0 PLATE AL SB209 5083-H113 PLATE AL SB209 3003-H14	PLATE CU CR SOFT ANNLD DHP SB152 PLATE CU LT CR DHP SB152 PLATE CU-SI SB96-A	PLATE STL FIREBOX SA212-B PLATE STL FIREBOX SA285-C PLATE STL HR SA7	PLATE STSTL SA240, 304 HR P & A PLATE 9% NICKEL A353 Gr B	
	MATERIAL CODE NO.		1-563-01-XXXX 1-564-01-XXXX 1-565-01-XXXX 1-568-01-XXXX	1-580-13-XXXX 1-585-15-XXXX 1-590-05-XXXX	1-544-67-XXXX 1-545-67-XXXX	1-552-69-XXXX 1-543-60-XXXX		1-640-01-XXXX 1-641-01-XXXX 1-643-01-XXXX	1-657-13-XXXX 1-656-13-XXXX 1-666-15-XXXX	1-615-67-XXXX 1-613-67-XXXX 1-611-67-XXXX	1-624-69-XXXX 1-609-60-XXXX	
£	701	is Pro	ducts and Cham	cicals Ch	omicals, Inc.	, uniess anei	her sow	rce is shown,	orty of Air Pr is subject to re hout prior writt	turn en de-	Jan.	1966

SHEET AL SE SHEET CU CF SHEET CU LI SHEET STSTI TUBING EXTE TUBING SMLS	PRESSURE VESSELS	REMARKS			Trays or Spun Items Shells			Round T5 Extruded Finned Drawn SMLS Tubes, Heat Exch. & Cond. Tubes 4 For U-Tube and/or Rolling Applications	Not Code - Connecting Tubing Straight Lngths. Coil Type Heat Exchanger Tubes	Not Code - Structural Use Only			
AL CODE NO. -01-XXXX -01-XXXX -01-XXXX -13-XXXX -01-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -13-XXXX -69-XXXX	MATERIALS OF CONSTRUCTION FOR PRESSURE VESSELS	DESCRIPTION	SHEET	AL SB209 AL SB209 AL SB209 AL SB209	cu cr cu lt cu-si		TUBING		SMLS		STRUCTURAL SHAPE	Steel - HR, SA 7 STSTL SB221 Type 304 Aluminum 6061-T6 Aluminum 5083-H112	
MATERIA MATERIA 1-729, 1-724, 1-724, 1-724, 1-724, 1-745, 1-864, 1-864, 1-845, 1-84		MATERIAL CODE NO.		1-729-01-XXXX 1-730-01-XXXX 1-724-01-XXXX 1-733-01-XXXX	1-746-13-XXXX 1-745-13-XXXX 1-755-15-XXXX	1-713-69-XXXX		1-866-01-XXXX 1-864-01-XXXX 1-861-01-XXXX 1-862-01-XXXX	1-893-13-XXXX 1-890-13-XXXX	1-845-69-XXXX 1-847-69-XXXX			

SHELL DESIGN

1. PURPOSE

This standard provides a guide for the design of shells for pressure vessels.

2. SCOPE

The standard encompasses the design of cylindrical shells for matching to torispherical heads, ellipsoidal heads, and hemispherical heads.

3. BASIC DIAMETER

The basic shell diameter; i.e. whether O.D. or I.D., shall be governed by the type of heads specified on the pressure vessel. The following list indicates which diameter to use in relation with a particular type head:

- A. Torispherical Head Outside Diameter
- B. Ellipsoidal Head Inside Diameter
- C. Hemispherical Head Inside Diameter

If allowed by the Process Specification, diameter sizes should be selected in even inches, preferably in 6 inch increments; i.e. 12 inches, 18 inches, 24 inches, etc.

4. X-RAY

The question of using X-Ray examination to determine shell thickness should be evaluated on the basis of economics, codes of construction, shipping and handling and good engineer practices. Thickness calculations should be made using full X-Ray, spot X-Ray, and no X-Ray and the nominal size plates resulting from these calculations should be compared using the following considerations:

- A. Material Cost
- B. X-Ray Cost
- C. Weld Electrode Cost
- D. Welding Labor (number of passes)

See Design Engineering Standard 510.1 (Paragraph 7)

510 PRESSURE VESSELS

SHELL DESIGN

5. STANDARD CALCULATION FORMS

All shell calculations must be made on the Air Products and Chemicals, Inc. Standard Forms in a neat and orderly manner. Use the following forms for the condition listed:

- A. Shell thickness, internal pressure, based on inside diameter. Form No. 8029.
- B. Shell thickness, internal pressure, based on outside diameter. Form No. 8030.
- C. Shell thickness, internal pressure, conical section. Form No. 8024 or 8028.

For external pressure on cylindrical and spherical vessels use the formulas as given in the ASME Code, Paragraph UG-28. Use reproducible cross-sectional paper, Air Products and Chemicals, Inc. Form 8100M only.

6. ORIENTATION OF SHELL SEAMS

On shells composed of two or more courses, the adjacent longitudinal seams must be staggered at least 5 times the nominal thickness of the plate. One exception to this rule will be lap jointed heat exchanger shells (non-code pressure vessel) which, due to ease of fabrication, should have the longitudinal seams in line. Orientations of all seams must be clearly shown on the drawing.

7. MINIMUM THICKNESS

The minimum thickness for all materials used in shell construction shall be as indicated.

- A. Buttweld Joints 1/8" minimum
- B. Lapweld Joints 1/16" minimum

NOTE: Aluminum shells shall use 3/16" minimum thickness regardless of joint types. Individual pressure vessel types may require a greater minimum thickness such as high pressure columns which generally will use 1/4". The individual pressure vessel type standards must be consulted to determine the shell thickness when using aluminum material.

SHELL DESIGN

8. LOADINGS

- A. Wind Loading If the pressure vessel is installed outside, subject to wind loading, the stress due to this factor must be computed. Use Form No.
- B. Seismic Loading All pressure vessels internal or external to the Cold Box subject to Seismic Loadings shall be evaluated, and the stress due to this factor must be computed. Use Form No._____.

9. SHELL MATERIAL

All shell material, shown in the Bill of Material on the drawing, used in a Full Code, UM Code or Code Equivalent pressure vessel shall have an (*) asterisk or (**) double asterisk to the left of the number required column. The footnote explaining these signs shall read (*) mill test reports required or (**) mill test reports and vendor supplied charpy test coupons of parent metal at ______ °F. The note shall be placed above the Bill of Material adjacent to the secondary number block.

10. CIRCUMFERENTIAL SHELL LENGTHS

Circumferential lengths of shell plates shall normally be specified in the Bill of Material for maximum circumference, i.e. largest head tolerance, along with a note "Cut plate to taped head dimensions." For example, if a 54 inch outside diameter head is being used, the shell length should be π (54-t) + 1/2 inch. (See Note Below) Assuming 1/2 inch is the shell thickness, a plate 168 1/2 inches long should be specified.

See Design Engineering Standard 510.3 for standard head tolerances.

11. BACKING STRIPS

Where backing strips are required in the design and fabrication of a pressure vessel, the following design considerations shall be incorporated.

- A. The backing strip material shall conform to the same alloy as the head and shell.
- B. All circumferential and longitudinal backing strips shall have their butt joints welded with full penetration welds.

NOTE: Standard head manufacturers oversize tolerance.

510 PRESSURE VESSELS

SHELL DESIGN

11. BACKING STRIPS (Cont'd)

- C. The backing strips shall be tack welded sufficiently in order to maintain and insure intimate contact of the backing strip to the shell and head. This is to insure acceptable weld results.
- D. The minimum thickness for backing strips of all material shall be 1/4" unless otherwise specified by the Metallurgical Department.

12. CONSULTATION

The design engineer shall consult the individual pressure vessel type standards to determine if close tolerance shells and heads are required.

1. PURPOSE

This standard establishes a uniform procedure for designing and specifying heads for pressure vessels (Non-Code and ASME Code) in order to achieve an optimum design.

2. SCOPE

This standard describes the selection and design of head types for cylindrical pressure vessels designed and/or manufactured by Air Products and Chemicals, Inc.

- A. Standard Flanged and Dished
- B. Dished Only
- C. Torispherical (ASME Flanged and Dished)
- D. Ellipsoidal (ASME 2:1)
- E. Flat (Stayed and Unstayed)

3. PROCEDURE FOR SELECTING HEADS

The choice of head type is generally determined on the basis of code requirements and cost. A head drawing of the acceptable type most suitable for the particular vessel shall be prepared for Purchasing. If doubts exist as to the particular advantage of each type, prepare drawings of each for Purchasing. Six prints of each drawing shall be forwarded to the Purchasing Department. Purchasing will contact various vendors for price and delivery information on the head to the drawing (stock or custom) within the immediate size, dish radius and thickness range. The Design Engineer and the Process Equipment Design Supervisor will evaluate the technical price and delivery information and decide which particular head will be specified for the job.

A. Full ASME Code (See 510.1)

Only ASME acceptable type heads may be used for this type vessel. These ASME style heads are often in stock at a price advantage over custom fabricated heads. Types normally available and acceptable are:

(1) Torispherical Heads (ASME flanged and dished) with a knuckle radius that is 6% of the inside crown radius.

- 3. PROCEDURE FOR SELECTING HEADS (Contid)
 - A. Full ASME Code (See 510.1) Cont'd
 - (2) Ellipsoidal Head (ASME 2:1) in which half the minor axis (inside depth of the head minus the skirt) equals one-fourth of the inside diameter of the head skirt.
 - (3) Flat Head (stayed and unstayed) per ASME Paragraph UG34.
 - B. Non-Code Vessels (See 510.1)

Standard flanged and dished, or dished flat heads are used on Air Products and Chemicals, Inc. vessels (Non-Code) only. Generally it is economical to use these type heads rather than the ASME heads.

4. CALCULATIONS: ASME HEADS

- A. Torispherical Heads (ASME flanged and dished 6% knuckle radius).
 - (1) Pressure on concave side
 - a. Calculations Use Form No. 8058. (See Page No. 6)
 - b. Drawing Use Form No. 8053. (See Page No. 10)
 - (2) Pressure on convex side
 - a. Calculations Compute the thickness in accordance with the rules in Par. UG-33, Section VIII, ASME Code.
 - b. Drawing Use Form No. 8053. (See Page No. 10)
- B. Ellipsoidal Heads (ASME 2:1)
 - (1) Pressure on concave side
 - a. Calculations Use Form No. 8057. (See Page No. 7)
 - b. Drawing Use Form No. 8052. (See Page No. 11)

- 4. CALCULATIONS: ASME HEADS (Cont'd)
 - B. Ellipsoidal Heads (ASME 2:1) Cont'd)
 - (2) Pressure on convex side
 - a. Calculations Compute the thickness in accordance with the rules in Par. UG-33, Section VIII, ASME Code.
 - b. Drawing Use Form 8052. (See Page No. 11)
 - C. Flat Heads, Unstayed
 - (1) Pressure on either side
 - a. Calculations Use Form No. 8062. (See Page No. 8) When nozzle O.D. in flat head exceeds one-half of the head diameter or shortest span, design the head according to Par. UG-39C, Section VIII, ASME Code.
 - D. Flat Head, Stayed
 - (1) Pressure on either side
 - a. Calculations Use Form No. 8061. (See Page No. 9)
- 5. CALCULATIONS: NON-CODE HEADS
 - A. Torispherical; Standard Flanged and Dished Heads
 - (1) Pressure Concave Side
 - a. Compute the thickness in accordance with the rules in Par. UA-4d Section VIII, ASME Code.
 - b. Drawing Use Form No. 8053. (See Page No. 10) Remove the word "ASME" from the title.
 - (2) Pressure Convex Side
 - a. Compute the thickness in accordance with the rules in Par. UG-33e Section VIII, ASME Code.
 - b. Drawing Use Form No. 8053. (See Page No. 10) Remove the word "ASME" from the title.

510 PRESSURE VESSELS

HEAD DESIGN

5. CALCULATIONS: NON-CODE HEADS (Cont'd)

- B. Ellipsoidal Heads
 - (1) Pressure Concave Side
 - a. Compute the thickness in accordance with the rules in Par. UA-4c, Section VIII, ASME Code.
 - b. Drawing Use Form No. 8052. (See Page No. 11) Remove the word "ASME" from the title.
 - (2) Pressure Convex Side
 - a. Compute the thickness in accordance with the rules in Par. UG-33d Section VIII, ASME Code.
- C. Flat Head, Unstayed and Stayed
 - (1) Use the same calculations and drawing forms as indicated in Section 4C and 4D.
- D. Dished Head
 - (1) Pressure Concave Side
 - a. Compute the thickness by formula $t = \frac{5}{6} \frac{PL}{S}$
 - (2) Pressure Convex Side
 - a. Compute the taickness in accordance with the rules in Par. UG-33c Section VIII, ASME Code.

6. STRAIGHT FLANGE

On any type flanged head, the straight flange length is to be 1 1/2 inches unless the 4:1 tapered section (if required) meets the knuckle radius or if unusual design considerations dictate a different length.

7. MILL TEST REPORTS

Mill test reports are required on head material and must be so indicated on the drawing.

8. SPECIAL HEADS

Conical heads, flanged only heads and flanged and flued heads are considered special and can be used only with the approval of the Process Equipment Design Supervisor. Use Form No. 8054 for layout and Form No. 8056 for calculating thickness of conical heads. (See Pages No. 12 and 13). Flanged only and flanged and flued heads may use flat head formulas for calculations.

9. NOTES TO SAMPLE DRAWINGS

- A. The minimum head thickness is the figure t_a (ordered thickness) which is computed on Form No. 8057, or 8058.
- B. The minimum flange thickness is the figure calculated using the condition of a seamless shell (100% joint efficiency) as computed on Form No. 8060. This minimum flange thickness may never be less than the smaller of:
 - 1. 80% of the nominal shell thickness or
 - 2. the nominal shell thickness minus 1/8".
- C. Use 1, 1/4 time the nominal shell plate thickness or 1/8 inch plus the nominal shell size, whichever is less, for this maximum flange thickness prior to machining.

10. HEAD TOLERANCES

Flanged and dished heads shall be ordered as close to manufacturer's standard as possible. Except in special cases where the inside diameter is critical, heads shall be specified with the normal manufacturing tolerance on the diameter.

0.D.	Thickness	Circumference Tolerance	Equivalent Diameter Tolerance
12" - 48"	Up to 1"	<u>+</u> 3/8"	<u>+</u> 1/8"
	1" to 2 1/2"	<u>+</u> 1/2"	<u>+</u> 3/16"
48" - 96"	Up to 2 1/2"	<u>+</u> 1/2"	<u>+</u> 3/16"
96" - 180"	Up to 2 1/2"	± 3/4"	<u>+</u> 1/4"

510 PRESSURE VM SELS

у	J. DOE Date	6-1-60		8058
ıbje	ct CAUSTIC SCRUBBER HEADS		Urnwing No. 59518	D
			Sheet 3 of 6	•
		•	Job No. 00-0-0000	-0
	ASME CODE 1962EDITIO	N - HEAD THICKNESS CA	LCULATIONS	
	INTERNAL PRESSURE -	DISHED HEADS (TORISP	HERICAL)	
	p - internal design pressure, psig		SIM SA 285, GR C	
	T - design temperature, or	<u> </u>	rking stress n temperature, psi	13750
		24 S1 - at test	temperature, psi	13750
	Type Weld joint SEAMLESS	['	Stress Relief	
1	E - Joint Efficiency-Par. UW-12	100% NO	NO	
	Stress Relieving Required:		g Required:	NO
	(Par. UW-10 (a))	(Par. UW-1	1)	
	HEAD THICKNESS CALCULATIONS - Par. U	G-32 (e)		
•	t - required thickness			
	$\frac{0.885p (L + c)}{SE - 0.1p} = \frac{.885 \times 110}{13750 \times 1}$	(24 + .063)		
				.169"
1	t + a = design thickness = .232"	t _a = Ordered	Thickness =	.232"
	MAXIMUM ALLOWABLE WORKING PRESSURE IN	N HEAD		
	New and Cold (Par. UA-60 (e))			
	$p_1 = \frac{s_1 E_{(t_a)}}{0.885 L + 0.1 t_a} = \frac{13750 \times 1 \times 1}{.885 \times .24 + 1}$			
• ;	P_1 0.885L + 0.1 t_A = $\frac{13750 \times 1 \times 1}{885 \times 20}$	232		150
	Hot and Corneled (Par. UA-60 (a)			
	• •			
, - ,	SE (+3 - 0)	a series -		
<u></u>	$\frac{SE (+_3 - 0)}{.885 (L + 0) + 0.1 (t_3 - 0)}$	13750 X .165 1885 X 24.063 + .	.1 X .169	110
}	lydrostatic test pressure X	(p ₁ = (Par. UG-99)		225
	Pneumatic test pres ure		G-Gallage-Active	167.5
		1		
ŀ	fead Shickness required for no ale re	i word me t calculati	ions Par. UG-37 & UA-4	(d)
t	$r = \frac{P_2 (L + c)}{25 - 0.2 \text{ p}} = \frac{10 \times 24}{2 \times 10\%}$.062		O(33 II
	23 = 0.2 p; 2 X 1375	J2 X . 0	-	.097"

By J. DOE	Date 6-1	- 00	Drawing No. 5	ADTO W
Subject AIR RECEIV	ER HEAD		Sheet No. 4	of <u>10</u>
- Indiana			Job No. 00-0-	0000-0.0
ASM	E CODE 1962 EDITION	- HEAD THICKNESS	CALCULATIONS	
	INTERNAL PRESSURE	- 2:1 ELLIPSOIDAL	HEADS	
<pre>D - inside shell d p - internal desig</pre>	iameter, inches		ASTM SA 240, (orking stress	GR 304
c - corrosion allo	wance, inch	O S - at desi	gu temperature,	nsi 18,750
T - design tempera	ture, of	S_1 - at tes	t temperature, p	osi 18,750
Type Weld Join	t	Radiograph	Stress i	Relief
E = Joint Efficiency Pa		00% NO	NO	
Stress Relieving R (Par. UW-10 (a			ng Required:	NO
/. u u 10 (a		Par. UW	-11)	NO
HEAD THICKNESS CAL	CULATIONS Par. UG-32	(d)		
		(4)		
t = required thick				
= p (D + 2c)	150 (30 + 0) 2 X 18,750 X			.120"
t + c = design thi	ckness = .120"	a Ordered Thickne	S8 -=	.120"
MAXIMUM ALLOWABLE	WORKING PRESSURE IN !	ÆAD.		
New and Cold (Par. UA-60 (e))			
2 3 ₁ 1	E (t _a)			
p = p ₁ =	$\frac{E(t_a)}{0.2(t_a)} = \frac{2X}{30 + }$	18,750 X 1 X .1	<u>L</u> 20	3.50
<i>p</i> · · ·	0.2 (ta) 30 4	2 X .120		150
Hot and Corrode	ed (Par. UA-60 (a))		
2SE	(t _a - c)	2 Y 18 750 Y 1	v 120	
$p = p_2 = \overline{(1) \cdot (1)}$	$\frac{(t_a - c)}{2c) + 0.2 (t_a - c)}$	$\frac{2 \times 10,100 \times 1}{30 + .2 \times .120}$	5	150
	·			
Hydrostatic test pr	ressure (Par. HG=99)	1.5 X p ₁ =		225
Pneumatic test pro:	sauro (Par, Wi-loc) 1.25 X p _L =		187.5
Head thickness requ	niced for nozzle refr	iforcement calculat	ions in accorda	nce with Par.
UG-37.				
P2 0.9	(1) (1c)	0 7 20		
2S = ().2	(D (2) (2) 150 X (2) 2 X 18	. y 	~ !	.108"
	- <u> </u>	·,,,, · · · · · · · · · · · · · · · · ·		
hecked J. SMITH		Approved	T ******	

510 PRESSURE VESSELS

	No. 8041	
y J. DOE Date 6-1-60	Drawing No. 59518 C	
ubject SUBCOOLER	Sheet No. 1 of	3
BOTTOM HEAD	Job No. 00-0-0000-7.0	0
ASME CODE 162 EDITION - FLAT HEADS CALCULATION		
- diameter, or shortest span measured as	C - as specified in UG-34 (2)	-5
indicated in Fig. UG-34, inches.	Material ASTM SB 209, 5083	-
- design pressure, psig 15 - design temperature, F 150	S - at des. temp., psi 10.0	000
- Corrosion allowance, inch.	S_1 - at test temp., psi 10.0	000
hickness Calculation for Unstayed Head (Cover Platequired Thickness $t-d$ $\sqrt{\frac{CP}{3}}$ $=$ $24\sqrt{\frac{.5 \times 15}{10,000}}$.658)11
esign Thickness:		
+ ca = .658"	Final thickness t ₁	1
AXIMUM ALLOWABLE WORKING PRESSURE:		
New and Cold (Par. UA-60 (e))		
$\frac{\text{AP - P_1 - } \frac{s_1 (t_1)^2}{d^2 C} - \frac{10,000 \times .75^2}{24^2 \times .5}}{\text{Hot and Corroded (Par. UA-60 (a))}}$. 19.	.5 PS
Hot and Corroded (Par. UA-60 (a))		
$\frac{\text{4AWP} - P_2 - \frac{S(t_1 - ca)^2}{(d + 2ca)^2 C} - \frac{10,000 \times .75^2}{24.5 \times .5}$.5 PS
mell Material: ASUM SB 200, 5083	s (or shell) 10,000	
O (Ineide Shell Dia.) 2l4	t _s (shell thk's)250	<u> </u>
Geld Depth:		
? Times Seamless Shell Thickness $\frac{PD}{S_8} = \frac{15 \times 2h}{10,000}$	= .072"	
S _s 10,000 1.25 t _s (Where t _s is actual shell thickness) =	1.25 X .25 = .313"	
Minimum Weld Depth, the greater of above: -313"		
Tydrostatic Test Pressure (1.5 x P ₁) = Pneumette Test Pressure (1.25 x P ₁) =	29. 21.	. 3
and the second s		
The second secon	And the second s	

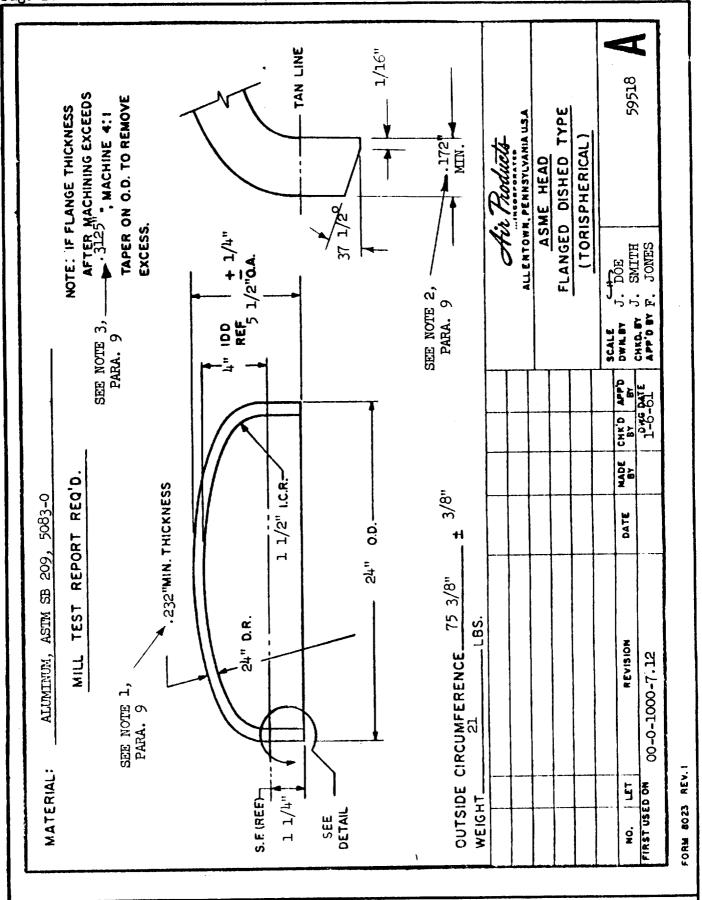
DESIGN ENGINEERING	STANDARES	
510 PRESSURE VE	COMS	Į.
		No. 8042
3y J. DOE Date 6-1-60	Drawing No. 5951	8 D
dubject CHECK VALVE	Sheat 1 of	5
HEAD	Job. No. 00-0-00	00-0
ASME CODE 1962EDITION - STAYED FLAT H CALCULATIONS	EADS AND COVER PLATES	
- max. pitch measured between straight lines passing thru the centers of stays in different rows, which lines may be horiz., vertical or inclined, inches	C - 2.1 for welded stays of screwed thru plate over 7/16" in this	s not
- design pressure, psig	C - 2.2 for welded stays of screwed thru plate 7/16" in thickness Material ALOM SD 200.	e over
- design temperature, °P 150 - corresion allowance, inch	S - at des. temp., psi S ₁ - at test temp., psi	003 10,000 10,000
(Min.)- $_{\mathbf{P}}\sqrt{\frac{\mathbf{P}}{\mathbf{SC}}}$ - 12 $\sqrt{\frac{15}{10,000 \times 2.1}}$	-	.32"
Design Thickness		
+ ca = .32"	Final Thickness t ₁	.375"
New and Cold (Par. UA-60 (e))		
$\mathbf{v} - \mathbf{r_1} - \frac{(\mathbf{t_1})^2 \mathbf{s_1} \mathbf{c}}{\mathbf{r}^2} - \frac{(.375)^2 \times 10,000 \times 2.1}{(12)^2}$	Wantana	20.5
Hot and Corroded (Par. UA-60 (a))		
WP = $P_2 = \frac{(t_1-c_4)^2 \text{ SC}}{p^2} = \frac{(.375)^2 \text{ x 10,000 x 2.}}{(12)^2}$	1	20.5
hell Material ASUM SE 209, 5083	3 ₈ (°F Shell Mat'l.)	10,000
(Inside Shell Dia.) 2^{l_i}	t (Shell Thk's.)	.250"
eld Depth (Weld to Shell) Times Seamless Shell Thickness $\frac{PD}{S_B} = \frac{1.5 \times 2^{14}}{10,000}$.25 t _a (Where t _a is actual shell thickness) = 1. Inimum Weld Depth, the crister of above: .313"	_ = .072" 25 X .25 = .313"	

2 Times Seamless Shell Thickness $\frac{PD}{S_0} = \frac{1.25 \times 24}{10,000} = \frac{0.02}{1.25 \times .25} = .002$ 1.25 t_g (Where t_g is actual shell thickness) = 1.25 X .25 = .313"

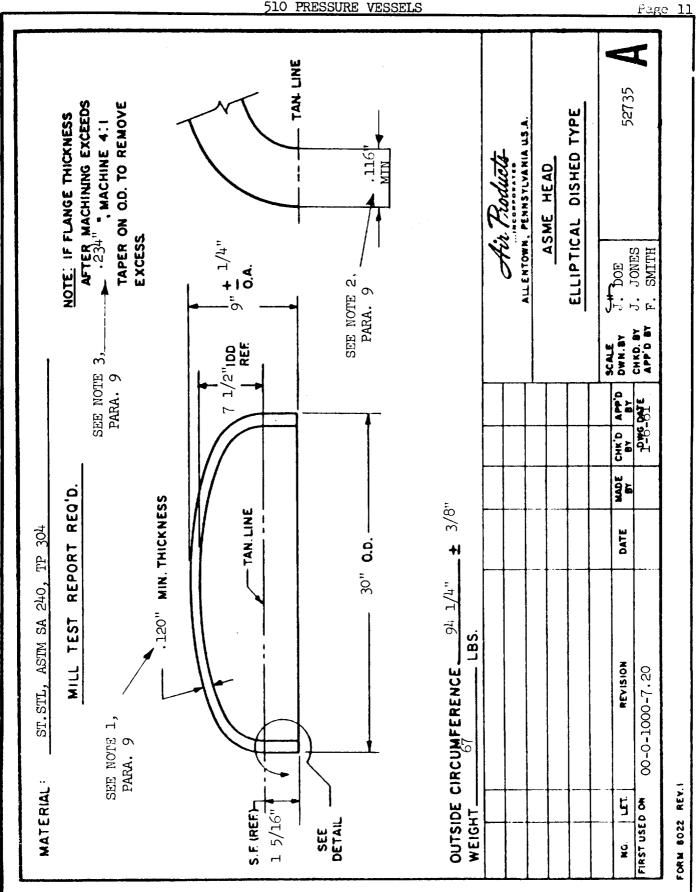
Endrestatic Test Pressure (1.5 x P₁) = \frac{30.75}{25.7}

Pheumatic Test Pressure (1.25 x P₁) = \frac{25.7}{25.7}

Air Products



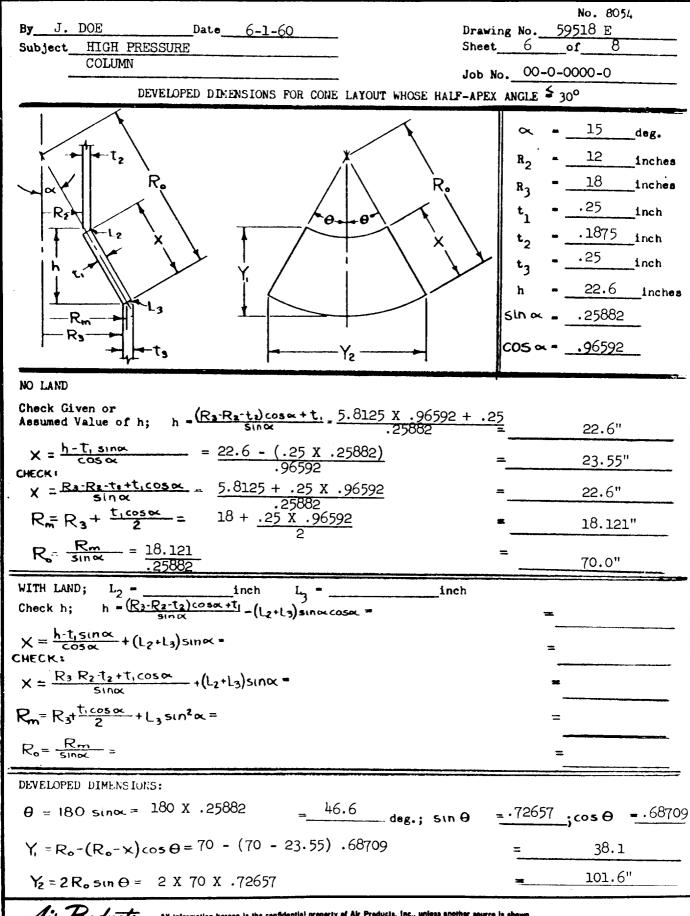
510 PRESSURE VESSELS



Air Products

·	No. E056 Drawing No. 59518 E Sheet 5 of 8 Job No. 00-0-0000-0 CONE THICKNESS CALCULATIONS WHOSE HALF APEX-ANGLE \(\frac{2}{30}\)
P = Internal design pressure, PSIG 110 T = Design temperature, °F 150 c = Corrosion Allowance, inch 0 D = Largest I.D. of cone, inches 36 α = 1/2 x Apex angle, deg. 15 Type weld joint DOUBLE BUTT Joint efficiency (Ref. Par. UW-12) 85%	Material: ASTM SB-96 Allowable working stresses; S - At design temperature = 12,000 PSI S1- At test temperature = 12,000 PSI Stress relief required: NO (Ref. Par. UCS-56(a)) Radiographing required: NO (Ref. Paras. UW-11(a), UW-12, & UCS-57)
CONE THICKNESS CALCULATIONS - Par. UC-32 (g) $t = \frac{P(D+2c)}{2\cos\alpha(SE-0.6P)} = \frac{110(36+0)}{2 \times .96592(12,000)}$ Design Thickness = $t + c = \frac{.2025}{.2025}$ in MAXIMUM ALLOWABLE PRESSURES: NEW AND COLD; $P_1 = \frac{2\cos\alpha \cdot 5_1E(ta)}{D+1.2\cos\alpha(ta)} = \frac{2 \times .96592 \times 12,00}{36+(1.2 \times .96592)}$ "HOT" AND CORRODED; $P_2 = \frac{2\cos\alpha \cdot 5_1E(ta)}{(D+2c)+1.2\cos\alpha(ta-c)} = \frac{2 \times .96592 \times 12,00}{36+(1.2 \times .96592)}$	00 X .85 X .25 = 136 PSI
Hydrostatic test pressure (Par. UG-99) = 1.5 x P ₁ Pneumatic test pressure (Par. UG-100) = 1.25 x P ₁ CONE THICKNESS REQUIRED FOR NOZZLE REINFORCEMENT (204 PSI 170 PSI
(Ref. Par. UG-37(b)): t. = Thickness of a seamless cone of diameter D Pr(D,+2c) = 136 (30 + 0)	measured where nozzle axis pierces the cone. 0006×136 = .177" OMPRESSION RING NOT REQ'D -51, OBTAIN \triangle FOR $\frac{P_2}{SE}$; \triangle =deg.

Air Products



PRESSURE INDICATORS

1. PURPOSE

To establish a standard for the application, use and purchase of solid front, dial type, pressure indicating gauge $4\ 1/2$ " size and larger, which comply with the minimum safety and design features. For $3\ 1/2$ " size and smaller, refer to Design Engineering Standard 531.

2. SCOPE

The scope of this standard applies to round, dial type pressure indicating gauges of solid front construction only.

This standard covers:

Both surface and flush mounting Pressure, vacuum and compound types With mounting per A.S.A. Specification As approved by Air Products and Chemicals, Inc. Safety Dept. With a range from 30 inches of mercury vacuum, to 10,000 psig.

3. GENERAL

- A. This standard will apply to two case styles, surface mounted having a back flange and a bottom male connection; and flush mounted having a front flange and a back male connection. The connection shall be 1/4" NPT for all pressure ranges up to 800 PSIG and 1/2" NPT for all pressure ranges from 801 PSIG to 10,000 PSIG.
- B. Gauge types covered herein:
 - (1) Pressure Gauge, having a scale to show pressures above atmospheric only.
 - (2) Vacuum Gauge, having a scale to show pressures below atmospheric only.
 - (3) Compound Gauge, having a scale to show pressures both above and below atmospheric.
- C. Data will be applicable to 4 1/2", 6" and 8 1/2" size gauges with mounting dimensions in accordance with A.S.A. standards. The 4 1/2" case size shall be used on all Air Products and Chemicals, Inc. installations unless otherwise specified by a customer or for special application larger sizes are acceptable on vendor's equipment if such are the vendor's standards.

PRESSURE INDICATORS

3. GENERAL (Cont'd)

- D. Approval of this standard has been issued by the Safety Department and cannot be changed without prior approval.
- E. The range shall be:
 - (1) Pressure Gauge C to 10,000 psig.
 - (2) Vacuum Gauge 0 30 inches of mercury.
 - (3) Compound Gauge 30 inches of mercury vacuum, to 300 psig.
- F. The case shall be of cast aluminum of solid front construction with rear blowout disc. The crystal shall be plastic.
- G. The selection of the bourdon tube material shall be on the basis of service. General services, including all air plant applications (except caustic), shall be phosphor bronze for vacuum and pressures up to 800 PSIG, and beryllium copper from 801 PSIG to 10,000 PSIG. Other metals such as alloy steel, stainless steel, and Monel shall be used for special conditions of either service fluid or atmosphere.

Socket shall be forged brass or bronze for use with phosphor bronze or beryllium copper tubes, and of the same material as the bourdon tube material for all others.

H. Accuracy of 1/2 of 1% of full scale (A.S.A. Class AA) is required on all gauges except where noted on the individual "G" standards. All gauges shall be equiped with a zero adjustment pointer.

Unless otherwise specified on the individual "G" standards, the gauge calibration shall be retained as follows:

- (1) Up to and including 600#, 30% overrange pressure.
- (2) 601# to 10,000# 10% overrange pressure.
- J. Dial shall be black figures on white background, except at customer's request this may be changed to white figures on black background or other combinations as per customer's request. Air Products and Chemicals, Inc. decal shall be affixed to dial face.

PRESSURE INDICATORS

3. GENERAL (Cont'd)

- K. When the gauge is to be used for Oxygen Service or any other service requiring hydrocarbon decontamination, the face of the dial shall be inscribed, "OXYGEN-USE NO OIL" and shall be cleaned in accordance with Air Products and Chemicals, Inc. QCL-116F.
- L. Standard Scale Ranges shall be in accordance with following Table I.

Table I

OPERATING LIMITS OF GAUGE	GAUGE DIAL RANGE
0 - 20 PSIG	0 - 30 PSIG
21 - 65 PSIG	0 - 100 PSIG
66 - 135 PSIG	0 - 200 PSIG
136 - 400 PSIG	0 - 600 PSIG
401 - 650 PSIG	0 - 1000 PSIG
651 - 1000 PSIG	0 - 1500 PSIG
1001 - 2000 PSIG	0 - 3000 PSIG
2001 - 3300 PSIG	0 - 5000 PSIG
3301 - 6500 PSIG	0 - 10000 PSIG
Vacuum	0 - 30" Mercury
Vac - 10 PSIG	30" - 0-15 PSIG
Vac - 20 PSIG	30" - 0-30 PSIG
Vac - 200 PSIG	30" - 0-300 PSIG

Table II

TYPE BOURDON TUBE AND DIAL SIZE

DIAL SIZE	PHOSPHOR BRONZE	BERYLLIUM COPPER	STAINLESS STEEL	ALLOY STEEL	MONEL	BRASS
4 1/2"	601-640	641-670	671-700	701-720	721-740	741-750
6",	801-840	841-870	871-900	901-920	921-940	941-950
8 1/2"	1001-1040	1041-1070	1071-1100	1101-1120	1121-1140	1141-1150

PRESSURE INDICATORS

3. GENERAL (Cont'd)

- M. All gauges will be identified with three (3) numbers.
 - (1) Pressure Indicator, "PI", number as shown on flowsheet will be shown also on drawings, purchase requisitions, purchase orders, shipping tag and instruction handbook.
 - (2) Gauge Designation, "G", number (see Table II) will be used for index identification and will be shown along with the scale range on drawings, purchase requisitions and purchase orders. This number will identify the specification sheet which shall be used in procurement of the gauge.
 - (3) Material code number will be shown on purchase orders. inventory control records, accounting records and recommended spare parts lists. All gauges shall be identified by and purchased under the material code number.

The gauge designation "G" number will identify the Design Engineering Standard sheets which shall be used in procurement of the gauge being forwarded to vendors with Request for Quotation and Purchase Orders.

Any gauge that is covered by these standards but is special done to the addition of extra features or accessories such as Maximum Reading Memory Pointer, Pulsation Dampener, Pressure Snubber, etc., and to which no code number has been previously assigned, must be assigned a material code number prior to being called out on the drawing.

Page 5

PRESSURE INDICATORS

4. INDEX OF GAUGES

STYLE NO.	PRESSURE RANGE	DIAL	MOUNTING	PRESSURE ELEMENT
G-601A	Pressure Under 1000#	4 1/2"	Surface	Phosphor Bronze
G-601B	Pressure Under 1000#	4 1/2"	Flush	Phosphor Bronze
G-602A	Vacuum & Compound 30" - 300#	4 1/2"	Surface	Phosphor Bronze
G-602B	Vacuum & Compound 30" - 300#	4 1/2"	Flush	Phosphor Bronze
g-603A	Pressure, Oxygen Service under 1000#	4 1/2"	Surface	Phosphor Bronze
g-603B	Pressure, Oxygen Service under 1000#	4 1/2"	Flush	Phosphor Bronze
G-640 A	Pressure (All Specials)	4 1/2"	Surface	Phosphor Bronze
G-641A	Pressure Over 1000#	4 1/2"	Surface	Beryllium Copper
G-641B	Pressure Over 1000#	4 1/2"	Flush	Beryllium Copper
g-642A	Pressure, Oxygen Service over 1000#	4 1/2"	Surface	Beryllium Copper
g-642B	Pressure, Oxygen Service over 1000#	4 1/2"	Flush	Beryllium Copper
G-671A	Pressure Under 1000#	4 1/2"	Surface	Stainless Steel
G-671B	Pressure Under 1000#	4 1/2"	Flush	Stainless Steel
g-672 a	Vacuum & Compound 30" - 300#	4 1/2"	Surface	Stainless Steel
g-672b	Vacuum & Compound 30" - 300#	4 1/2"	Flush	Stainless Steel
g-673A	Pressure Over 1000#	4 1/2"	Surface	Stainless Steel
g-673B	Pressure Over 1000#	4 1/2"	Flush	Stainless Steel
G-801A	Pressure Under 1000#	6"	Surface	Phosphor Bronze Phosphor Bronze
G-801B	Pressure Under 1000#	6"	Flush	
g-802A	Vacuum & Compound 30" - 300#	6 "	Surface	Phosphor Bronze
g-802B	Vacuum & Compound 30" - 300#	6"	Flush	Phosphor Bronze
g-803A	Pressure, Oxygen Service under 1000#	6"	Surface	Phosphor Bronze Phosphor Bronze
g-803B	Pressure, Oxygen Service under 1000#	6"	Flush	
G-841A	Pressure Over 1000#	6"	Surface	Beryllium Copper
G-841B	Pressure Over 1000#	6"	Flush	Beryllium Copper
G-842A	Pressure, Oxygen Service over 1000#	6"	Surface	Beryllium Copper
G-842B	Pressure, Oxygen Service over 1000#	6"	Flush	Beryllium Copper

537.1 Sheet 1 of 6

INSTRUMENTATION

ESTABLISHING PRESSURE SETTINGS OF SAFETY DEVICES

1. SCOPE

This standard presents a uniform basis for establishing the set pressure of safety and relief valves and the maximum bursting pressure rating of safety discs.

2. DEFINITIONS

- a. Operating Pressure The highest pressure, in psig, to which a
 vessel is subjected during normal extended operation.

 If the pressure in the vessel is pulsating, the operating pressure
 is considered to be the peak pressure.
- b. Maximum Allowable Working Pressure (MAWP) The maximum pressure permissable at the top of the vessel in its normal operating position at the operating temperature specified for that pressure. Refer to Section VIII ASME Code for Unfired Pressure Vessels, 1956 Para. UG-98 for complete definition.
- c. Over-Pressure Any pressure that is over the MAWP of a vessel. Over-pressure is usually expressed as a percentage of MAWP.
- d. Set-Pressure The pressure in psig at which the safety valve or relief valve begins to open.
- e. Back-Pressure The pressure developed on the discharge side of a safety device. The back-pressure may be variable or constant, superimposed or built-up.
- f. Accumulation The pressure increase at the inlet of a safety device which occurs as the fluid discharges through the device. Accumulation is usually expressed as a percentage of the set pressure in psig.
- g. Safety Valve An automatic device actuated by the static pressure at its inlet and characterized by full opening or "pop" action. Used for gas or vapor service. Construction always includes a blow-down ring or predetermined machined equivalent, which forms a "huddling" chamber for pop action.
- h. Relief Valve A device which opens automatically in proportion to the increase in pressure over the set pressure. There is no huddling chamber and no pop action. Used primarily for liquid service.
- i. Safety-Relief Valve Can be used for compressible and/or incompressible fluids. On liquid service the blow-down ring is made inoperative.

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Chief Design Engineer

Date 4-21-59

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537.1 Sheet 2 of 6

INSTRUMENTATION

ESTABLISHING FATSSURE SETTINGS OF SAFETY DEVICES

- j. Balanced Safety Valve A design where outlet line back pressure has little or no effect on the valve set pressure.
- k. Primary Relieving Device A safety device which will prevent a vessel from being over-pressured beyond the limits prescribed by prevailing codes during normally anticipated operation, mis-operation, and/or equipment failure.
- 1. Secondary Relieving Device A safety device which supplements the primary relieving device thereby preventing over-pressure resulting from a fire or other unexpected source of heat.
- m. Blow-Down The difference between set pressure and reclosure pressure.
- n. Full Flow Relief The maximum flow rate that must be relieved and which is a result of any anticipated operation, misoperation, and/or equipment failure.
- o. Thermal Relief The maximum flow rate that must be relieved and which results from expansion of a contained fluid being heated by the ambient atmosphere.
- p. Liquid Expansion Relief Applies only to equipment which operates completely filled with liquid.
- q. Pressure Circuit All the vessels, piping, and/or devices that are simultaneously protected by a full flow relief device(s) and may be subjected to the same pressure when the flow through the circuit is zero.
- r. Pressure Setting For a safety or relief valve, it is the same as set pressure. For a rupture disc it is the bursting pressure.

GENERAL

- a. The optimum pressure setting (set pressure or burst pressure) of a safety device is the maximum value which can be established consistent with the following:
 - 1. The setting meets the minimum requirements of all applicable codes and regulating agencies and is consistent with the best proven design practices.
 - 2. The setting does not exceed the lowest MAWP of all the equipment piping and valves in a pressure circuit which the safety device protects.

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ESTABLISHING PRESSURE
SETTINGS OF SAFETY DEVICES

- 3. The setting provides an adequate pressure differential above the operating pressure in the equipment protected. Inadequate differential results in excessive leakage and "popping", either of which leads to higher maintenance costs.
- 4. The setting does not dictate abnormal (and thereby uneconomical) equipment design.
- 5. The setting is high enough to insure that a safety valve reclosure pressure is higher than the operating pressure.

4. CONSIDERATIONS

- a. As the system approaches the set pressure, the net forces on the seating surfaces of a safety valve approach zero. A "simmering" leak will develop before this pressure is reached even with the most perfectly lapped and matched seats and discs. The optimum differential is established from a consideration of various factors discussed within the paragraphs following.
- b. Moderately increasing the MAWP normally decreases the cost of safety devices and maintenance and increases the cost of vessels and piping. Each application must be analyzed to determine the optimum relieving pressure from the standpoint of economics and good practice.
- c. Unnecessary leakage of some fluids may be hazardous and costly. It is often possible to establish a pressure setting high enough to prevent the valve from opening except as a last resort. The use of a rupture disc or a rupture disc-safety valve combination if often dictated under these circumstances. The use of a rupture disc, however, necessitates extremely high margins between operating and relieving pressures.
- d. Safety valve operation is very sensitive to mechanical strains placed upon the valve. Poorly designed inlet or outlet piping will result in chattering due to excessive pressure drops developed. The slightest distortion will affect the safety valve set pressure.
- e. Safety valve relieving pressures are influenced by both magnitude and frequency of pressure fluctuations at the inlet. The effect is more pronounced with liquids than with compressible fluids.

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4

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ESTABLISHING PRESSURE SETTINGS OF SAFETY DEVICES

f. Valves with screwed-in seats (semi-nozzle or short bushings), as commonly used in screwed-inlet valves and certain flanged valves, are incapable of the closer margins obtainable with the full nozzle valves.

5. CAUSES OF OVERPRESSURE - CHECK LIST

- a. Closing of outlet valve
- b. Plugging of outlet line (freezing, sealing, etc.)
- c. Failure of automatic control valve or controller
- Internal explosion
- e. Chemical reaction resulting in additional heat or vapor
- f. Failure of exchanger tubes
- g. Cooling water failure
- h. Reflux system failure.
- i. Exposure to external heat or fire
- j. Excessive heat input (defrost, etc.)
- k. Accumulation of non-condensibles
- 1. Thermal expansion of fluids
- m. Filling of vessels with fluid
- n. Any combination of the above

6. PROCEDURE

- a. Determine the code, if any, that will govern the application of the safety device involved and become thoroughly familiar with the requirements of that code. If the requirement involved is not subject to code regulation, then the applications must be made on the basis of positive protection of the equipment under consideration.
- b. Determine the type of safety device which will be required as the primary relieving device.
 - 1. Check MAWP's of all equipment involved.
 - 2. Refer to Table I or any codes that may apply.
 - 3. Refer to Table II
- c. Determine the best location for the safety device in the pressure circuit under consideration
 - 1. The highest possible pressure setting for the circuit will be determined by equipment with the lowest MAWP.
 - Consider pressure drops in all parts of pressure circuit using the maximum flow that normally flows through the pressure circuit as the flow value. Be certain to consider pressure drop between equipment and safety device inlet using this same flow.

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ESTABLISHING PRESSURE SETTINGS OF SAFETY DEVICES

- 3. Consider all the possible conditions which will occur as the plant becomes operative and ages, such as freezing, scaling, plugging, etc. which will affect the pressure drops through the system. Refer to Para. 5.
- 4. Consider the conditions wherein the flow through the pressure circuit is zero.
- d. Extablish pressure setting after location is established.
- e. Calculate maximum flow that must be relieved using pressure setting derived above. Refer to Design Standard 537.2 for procedure.
- f. Recalculate pressure setting based on maximum flow derived in (e).

7. ADDITIONAL CONSIDERATIONS

- a. Rupture disc manufacturers generally state the manufacturing tolerances of burst pressures in their catalogs. If it is required that the disc must have a specific rupture pressure stamped on the disc, the cost of the disc is increased substantially. Therefore, if a standard disc will be used, it must be considered from the standpoint that it may have a burst pressure above or below that required.
- b. The burst pressure of a rupture disc at 72°F is and must be stamped on the rupture disc. The rupture disc must be guaranteed to burst with plus or minus 5% of this pressure at 72°F. The burst pressure will change at other temperatures. To comply with the codes, the disc must be rated at the lowest temperature to which it will be subjected.
- c. If equipment is likely to be subjected to vacuum and it is not designed for it, it must be protected by a vacuum relief device.
- d. This standard is based on assumption that the safety device will relieve directly to atmosphere. If the safety device exhausts into a header, flare system, or any other equipment that will create a back pressure on devices, additional consideration must be given when establishing pressure settings. Refer to Design Standard 537.3 for procedures.
- e. All rupture discs to be teflon coated on both sides for protection against corrosion and potential premature failure.
- f. Rupture disc of carborundum shall be considered where installed costs are less than metal disc.
 - 1. Standard flanges for carborundum disc cost only 20% of the metal disc flange holder.
 - 2. Fragmentation pieces of carborundum disc must be completely discharged by design of vent discharge down to safe level. The vent discharge costs should be considered when disc is specified.

Sheet 6 of 6

ESTABLISHING PRESSURE SETTINGS OF SAFETY DEVICES

8. TABLES

A. TABLE 1. PRESSURE SETTINGS & OVER PRESSURES Maximum set pressures & overpressures permitted by the ASME Code, based on MAWP's.

		Max. Set Pres	ssure Max.	Over	Pressure
a.	Unfired Pressure Vessels				
	 One Valve Additional Valve 	1.00 x M 1.05 x M			x MAWP x MAWP
ъ.	Supplemental Device sized for fire or other unexpected source of heat	e 1.10 x M/	AWP	1.20	x MAWP
c.	A single device used to satisfy both a & b above based on:	у			
	 Normal Relief Reqs. Fire Conditions 	1.00 x M 1.00 x M			x MAWP x MAWP
d.	Thermal relief safety valves (See Note 2)	1.25 x Pr device se	rimary relie	eving	

- NOTE 1. The above apply to all full flow relief devices.
 - 2. The thermal relief device can be used as relieving device when pressure testing the plant piping circuits, in addition to its design function for protection of part or parts of a circuit from thermal expansion overpressure.

When testing the circuit the thermal expansion relief valve or valves shall be treated as primary relieving devices.

B. TABLE II. RUPTURE DISC OPERATING FRESSURES The following minimum requirements are recommended for bursting pressures

Type of Service	% of Operating Pressure		
Non-pulsating with temp, at disc not exceeding ambient	150		
Mildly pulsating pressures	175		

Highly pulsating pressures or where 200 temp. at disc exceeds ambient

NOTE 1. Requirements above are based on using solid pre-bulged rupture discs. The values may be tempered somewhat when using the newer types of fabrication discs that are becoming available. Consult with manufacturers for their recommendations.



SPECIAL REQUIREMENTS

SAFETY AND RELIEF VALVES

1. PURPOSE

The purpose of this standard is to establish special requirements for safety and relief valves.

2. SCOPE

This standard will encompass the following:

- A. Valve Body Requirements
- B. Materials of Construction
- C. Design
- D. Test and Inspection

3. GENERAL

- A. The special requirements specified herein shall form an integral part of the unit specifications.
- B. Valves for service temperatures of minus 20°F and colder are designated as "COLD" valves herein. Valves for service temperature entirely above minus 20°F are designated as "WARM" valves herein. Where neither "COLD" nor "WARM" valves are specified, the particular requirements shall be construed as applying to all safety and relief valves. Manufacturer shall stamp suffix letter "C" after model number on nameplate of all valves for use at temperatures below minus 20°F. All others shall be stamped with suffix letter "W" for warm.

4. VALVE BODY REQUIREMENTS

All inlet body connections shall be exactly the size specified in the unit specification. However, threaded inlet connections may be proposed as either male or female. Outlet connections on all valves may be manufacturer's standard size, type or rating.

5. MATERIALS OF CONSTRUCTION

- A. For cold service valves, the critical materials (both external and internal) not clearly defined in the unit specifications shall be as follows:
 - (1) Internal parts of iron and cold rolled steel will not be permitted except for spring material.
 - (2) All body studs and nuts shall be of series AISI 300 Stainless Steel.

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SPECIAL REQUIREMENTS

SAFETY AND RELIEF VALVES

5. MATERIALS OF CONSTRUCTION (Cont'd)

- B. When stainless steel is specified in the unit specification, dissimilar types of stainless steels, of series AISI 300, shall be used for the seat and disc, guides, and guided parts to prevent galling.
- C. Materials of valve shall be as specified in the unit specification. The following list of materials and conditions are tabulated for the purpose of standardization on the minimum cost acceptable materials for safety and relief valves within the set pressure and temperature limitations as tabulated.

SET PRESSURE	TEMP.	BODY MATERIAL	TRIM MATERIAL	SPRING MATERIAL	SPRING HOUSING MATERIAL	COMPRESSION SCREW MATERIAL
To 250#	-20°F to +400°F	Bronze	Bronze	Car. Steel Cad. Plated	Bronze	Carbon Steel
To 250#	-20°F to -325°F	Bronze	Bronze	Car. Steel Cad. Plated	Bronze	Stainless Steel
250# & Up	-20°F to +400°F	Carbon Steel	Stainless Steel	Car. Steel Cad. Plated	Carbon Steel	Carbon Steel
250# & Up	-20°F to -325°F	Stainless Steel	Stainless Steel	Car. Steel Cad. Plated	Stainless Steel	Stainless Steel

DESIGN

- A. Flat, metal-to-metal seats are required. Beveled disc with wing guides are to be specified and used only with the specific approval of the Engineering Department for standard plants and spare parts where previously specified for a job.
- B. Seating surfaces shall be metal-to-metal, and machine lapped to an optical finish.
- C. The blowdown ring on each valve shall be carefully preset, checked and sealed by the vendor within the limits designated for each unit.
- D. Valves to be used on vibrating installations (reciprocating compressors, etc.), as specified in the unit specification, shall have all parts subject to loosening, wire sealed or pinned, i.e. all bolts, nuts and caps shall be wire sealed. Screwed-in nozzles shall be pinned. Lift levers shall be spring loaded to eliminate vibration of lever.

SPECIAL REQUIREMENTS

SAFETY AND RELIEF VALVES

6. DESIGN (Cont'd)

E. All full flow safety relief valves on steam service or air service at temperatures higher than minus 20°F shall be equipped with lift levers.

7. TEST AND INSPECTION

- A. Operational Test Using clean, dry air for testing, each safety-relief valve shall be set, adjusted and pop tested, by the manufacturer, as necessary, until three (3) successive pop tests each fulfill the set pressure tolerances as set forth in the latest edition of the ASME Code, Section VIII, Unfired Pressure Vessels, Paragraph UG-133, Section (f); plus or minus 2 PSI for set pressures up to and including 70 PSI. 3 percent for pressures above 70 PSI.
- B. The valve shall also be set and adjusted to fulfill the blowdown requirements as specified in the unit specification.
 - (1) Sealing Upon the successful completion of the set pressure and blowdown requirements test, the vendor shall seal these adjustments in a manner which will prevent making any adjustment without breaking a wire seal.
 - (2) Seat Leakage Test The manufacturer shall test each safety-relief valve for seat leakage following completion of the operational test, as outlined in paragraph 7-A and without removing the valve from the test stand.
- C. All body and bonnet openings shall be carefully blanked off with a suitable flange, plug or cover to insure tightness. A non-setting thread lubricant suitable for the service conditions may be used, if necessary, to prevent leakage at external threaded connections, including those for engaging the cap. Safety valves with non-packed lift levers shall be immersed under water to pass 7-F test.
- D. A tube having an inside diameter not larger than 3/8 inch, and not exceeding 24 inches in length, shall be used for detection of seat leakage. One end of this tube shall be connected to the discharge side of the body (the drain plug connection can be utilized), and the other end shall be immersed not more than 1/2 inch in clean water in a transparent container.

)

SPECIAL REQUIREMENTS

SAFETY AND RELIEF VALVES

7. TEST AND INSPECTION (Cont'd)

- E. Air shall be applied to the valve inlet and maintained during leakage test at either the test pressure as listed in the unit specification, or 85% of the set pressure, whichever value is higher. For all metal to metal seat, beveled disc wing guided valves test pressure shall be 85% of set pressure. For wing guided valves with seat seal of polymers such as teflon, Kel-F test pressure shall be 90% of set pressure. Valves for set pressures of 30 PSIG or lower shall be leakage tested at 3 PSI less than the specified set pressure or at the test pressure as specified in the unit specification, whichever value is higher.
- F. The maximum allowable leakage shall be a total of 20 bubbles during a period of two (2) minutes, or as specified in the unit specification whichever is less, commencing with detection of the first bubble. The valve shall be considered tight if no bubbles appear during the first two (2) minute period at the leakage test pressure.
- G. Certification of tests of each valve as outlined in this standard shall be included with each shipment.

8. HYDROCARBON DECONTAMINATED - CLEANING LEVEL REQUIREMENTS

The applicable Air Products and Chemicals, Inc. Quality Control Standard will be noted in the Unit Instrument Specification.

540 CIVIL STRUCTURAL

PERSONNEL PROTECTIVE SHIELDS

OXYGEN SYSTEMS

I. PURPOSE

This standard establishes the requirement for personnel protective shields around each oxygen compressor installation. Shields are intended to prevent flames and molten metal from contacting personnel in case of fire within oxygen compressor, interstage piping coolers, and miscellaneous piping in immediate area of compressor.

II. SCOPE

This standard applies to all oxygen compressing systems designed, installed, or operated by APCI.

III. RESPONSIBILITY

Shield layout shall be reviewed by APCI Safety Engineering and Operations Departments during the first equipment arrangement review meeting and shall be approved by these departments prior to finalizing the layout

IV. DESIGN CRITERIA

A. Centrifugal Compressors

1. Materials

On the main operating area of the compressor the inside of the shield shall be constructed of 20 gauge galvanized type "B", ribbed, roof deck as manufactured by Inland Steel Products or approved equal. Outside of shield shall be 20 gauge galvanized flat sheet steel. Sandwiched between the inside roof deck and the outside flat sheet shall be 7.5 lbs. per square yard asbestos cloth which is glued to the outer sheet steel. Glue shall be Ceilcote #348 applied in minimum quantities to hold asbestos flat against steel during installation. The shield shall have panel of ribbed deck only at the top. 2'-0" wide toed-in 45° to reduce the possibility of hot metal striking the shield and deflecting upward and outside the shield. On the lower operating level, the shield shall be constructed of the 20 gauge, galvanized, type "B" ribbed roof deck only.

All ribbed roof deck shall be installed with the ribs in a horizontal position.

2. Strength

The roof deck shall be attached with self tapping screws to the inner surface of corner and intermediate columns. Attachment shall permit removal of shield for major maintenance activities. The sheet steel

DESIGN ENGINEERING STANDARDS

540 CIVIL STRUCTURAL

PERSONNEL PROTECTIVE SHIELDS

OXYCEN SYSTEMS

shall be attached to exterior of roof deck utilizing self tapping screws around edge of each sheet at intervals required to prevent edge bulging. Design of columns, column placement, column footings, panels, doors, etc., shall be capable of withstanding (yielding permitted) the maximum pressure release obtainable from a 2 inch diameter hole in the compressor piping. Total force exerted on the shield, regardless of distance between shield and pressure release, shall be determined from the following:

F = CA
$$\left[(K+1) (P+14.7) \left(\frac{2}{K+1} \right) \right]^{\frac{K}{K-1}} - 14.7$$

F = Maximum force, lbs.

$$K = \frac{C_D}{C_V} = 1.4$$

P = Maximum discharge pressure, psig

C = Orifice coefficient = 0.73

A = Area opening = 3.36 in.^2

This relationship reduces to the following simplified form:

$$F = 3.1P + 10$$

Strength calculations shall be based on the above force distributed over a one square foot area with this area located at height of compressor centerline. Column design and footings shall consider the force to act directly on each column. Panel design shall consider the force to act at midpoint between each pair of columns.

3. Placement and Height

a. Compressor Level

The placement and height of the shield on the compressor level shall be made bearing in mind the following factors:

- (1) A shield close to the machine reduces the possibility of debris being thrown over the shield.
- (2) A shield close to the machine will receive a greater concentration of heat than one further away.
- (3) It is desirable to leave enough space within the shield to allow a man to move about the machine to perform inspection and major maintenance without dismantling the shield.

PERSONNEL PROTECTIVE SHIELDS

OXYGEN SYSTEMS

- (4) It is desirable to position the shield within edges of concrete foundation considering all other requirements have been met.
- (5) Shield height is dependent on size of the compressor and will fall in one of the following two categories.
 - (a) Compressors and connecting piping less than 8 ft. height. These require 8 ft. vertical sides.
 - (b) Any compressor and connecting piping exceeding 8 ft. height: Vertical height shall equal height of compressor including piping.
- (6) The shield height shall be increased as required to eliminate line of sight from compressor case and piping to any permanently installed platform or public building within 100 feet.

Considering these items, the shield for all new facility layouts shall normally be positioned approximately 3 feet from the compressor case on three sides. This distance shall be increased where required to achieve an 18 inch walkway between the shield and compressor piping which does not penetrate the shield. The fourth side shall be located between the gear case and the compressor in a manner to prevent line of sight from compressor to the gear case. Small shield sections shall be provided in this side to permit easy removal for maintenance accessibility.

b. Lower Level

The placement and height of the lower level shield shall be governed by the following requirements:

- (1) Shield shall normally enclose all oxygen coolers. However, low pressure coolers and associated piping operating below 50 psig may be located outside the shield when their size and/or optimum piping design would otherwise result in a substantial cost increase.
- (2) Shield shall be located as close as practicable to coolers considering the following:
 - (a) Minor maintenance will be performed without removing the shield. Therefore, minimum clearances are required for passageways as follows:
 - 1. 2' at end of coolers or cooler piping, depending on which is closest to the shield.
 - 2. 2' parallel to cooler sides.
 - (b) Additional clearance shall be provided when required for access to gaskets, rupture discs, valves and other minor maintenance items.

540 CIVIL STRUCTURAL

PERSONNEL PROTECTIVE SHIELDS

OXYCEN SYSTEMS

- (3) Shield design shall permit removal of cooler bundles with minimum amount of shield disassembly. This objective shall be met by the following criteria.
 - (a) Columns shall be offset from cooler longitudinal centerline so that cooler tube bundles can be removed without moving the columns.
 - (b) Horizontal length of panels shall not exceed 10 feet to achieve a size and weight acceptable for man handling.
- (4) Shield height shall start approximately 2 inches above grade level or foundation slab and continue to 2 inches from bottom of structural steel for upper deck.

NOTE: The clearance provided at top and bottom is desirable for natural air circulation for cooling and preventing a concentration of oxygen in case of leaks.

- c. Equipment and Piping Placement
 - (1) The following items shall be located outside the shield.
 - (a) Control Panel

The oxygen compressor control panel shall be positioned to protect the operator area in front of the control panel from the direct path of molten material which could be blown over top of the personnel shield.

This objective shall be achieved by one or more of the following:

1. Rear of panel may face the compressor.

NOTE: A 3 foot minimum distance is required between rear of panel and shield for maintenance access.

- 2. Large equipment may be positioned between compressor and panel.
- 3. Panel may be located at ground level.

NOTE: In addition to the inherent protection provided by the above control panel placement, a protective roof shall be provided over front of panel as required by Design Engineering Standard 539.1.

- (b) All instruments and controls not mounted on the control panel but requiring observation or adjustment during oxygen compression
- (c) Lube oil console.

540 CIVIL STRUCTURAL

PERSONNEL PROTECTIVE SHIELDS

OXYGEN SYSTEMS

- (d) Suction butterfly and associated instruments.
- (e) Check valve in product outlet piping from compressor.
- (f) Water flow control valves, sight glasses and thermometers for closed water system.
- (2) The first elbow in each pipe from compressor case shall be within the shield if the piping contains oxygen or seal gas. This requirement does not apply to the following:
 - (a) First stage inlet piping
 - (b) Oil system piping

4. Walkways

If normal walkways outside the upper level shield or front of oxygen compressor instrument panel fall within perimeter limits of lower shield, these areas shall be covered with solid skid-proof deck plate. Deck grating inside the upper level shield shall remain uncovered to permit air circulation.

5. Doors

Access doors, of similar construction to the shield in which they are installed, shall be placed after consultations with the Operations Department. The shield shall have at least two doors on each level; however, the number of doors shall be kept to a minimum. Doors shall open outward. Latches shall be operable from either side of door. Door design shall conform to Figure 1.

6. Inspection Ports

Inspection ports shall be provided at strategic locations in walls of shields. Locations and installation shall be the responsibility of the Operations Department. Port design shall conform to Figure 2.

7. Stairways

Stairways to upper level shall be located for expeditious exit of operating personnel. When instrument panels are located on upper level, one stairway shall connect in the immediate vicinity of panel front.

8. Penetrations

a. Upper level

Shield penetrations by piping and conduit shall be as close to the deck as practical and shall be located in areas not required for normal walkways. Clearance between shield and penetrations shall not exceed inch. Openings may be continued to deck as a slot, where bottom of piping or conduit is within 2 inches of deck.

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540 CIVIL STRUCTURAL

PERSONNEL PROTECTIVE SHIELDS

OXYCEM SYSTEMS

b. Lower level

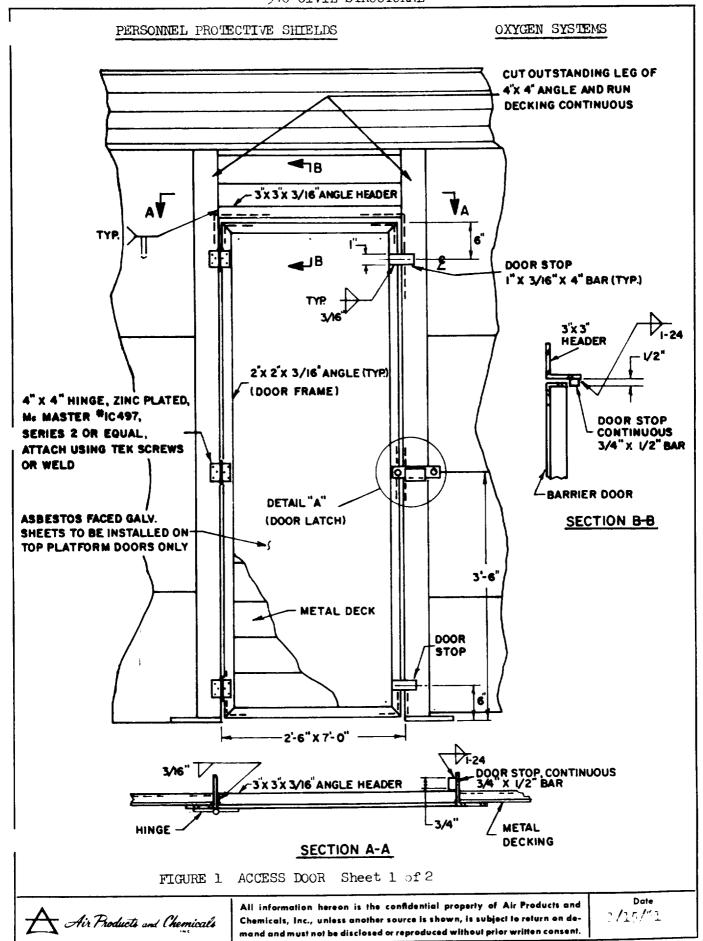
This piping will normally be overhead. Where the shield is penetrated, clearance shall not exceed $\frac{1}{2}$ inch.

B. Reciprocating Compressors

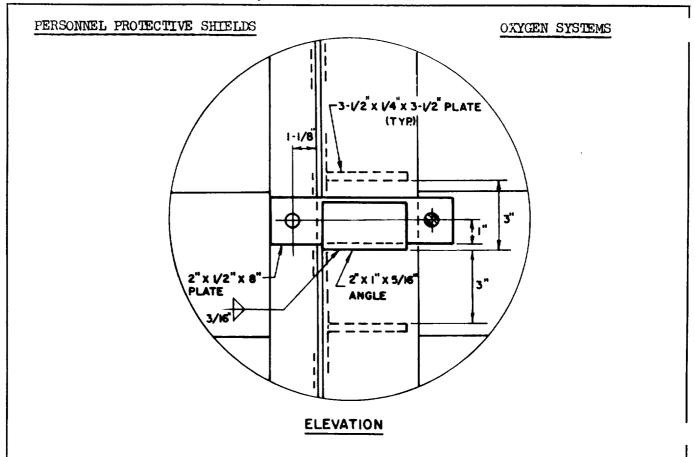
Shield requirements for centrifugal compressors are applicable to reciprocating compressors except as follows:

- 1. Compressor level shield will normally include intercoolers, aftercoolers, surge bottles and associated piping. However, these components may be located outside the shield when their operating pressure is below 50 psig and when their size and/or optimum piping design would otherwise result in substantial cost increase.
- 2. The shield shall be placed to exclude the motor.
- 3. Due to normal layout of compressor, surge bottles and coolers, distance between shield and compressor will generally be greater than for centrifugal compressors. Where distances from compressor to shield are 5 feet or greater, the vertical shield shall consist of 20 gauge, galvanized, type B ribbed roof deck only without asbestos and flat steel sheet outer layer.

540 CIVIL STRUCTURAL



540 CIVIL STRUCTURAL



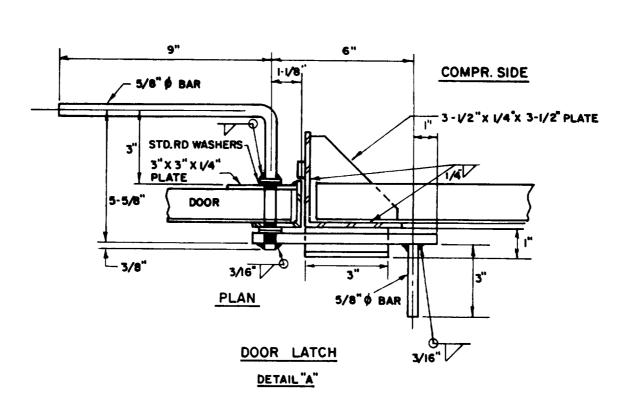


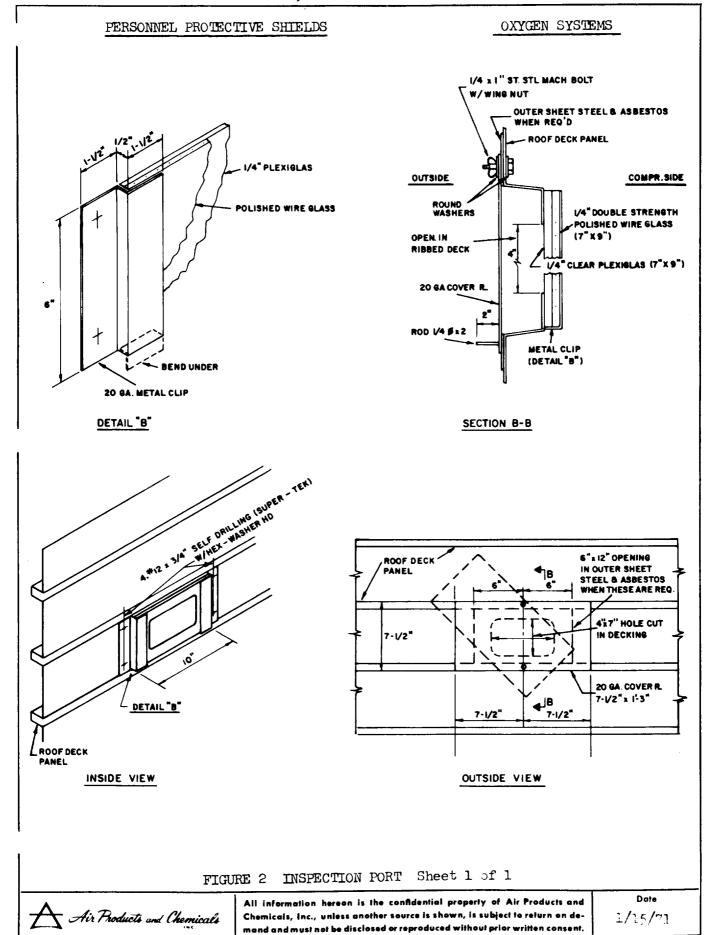
FIGURE 1 ACCESS DOOR Sheet 2 of 2

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540 CIVIL STRUCTURAL



FIELD TESTING

RECIPROCATING OXYGEN COMPRESSORS

I. PURPOSE

This standard establishes requirements for field testing of reciprocating oxygen compressors.

II. SCOPE

This standard applies to all reciprocating oxygen compressors installed or operated by APCI. Therefore, contracts, for sales plants which are erected by the owners with APCI advisors, shall require conformance as stated below in paragraph IV. B.

III. RESPONSIBILITY

Project Engineering shall provide the Operations Department, the Start-up Group and the owner (if different than APCI) with inspection and cleanliness reports on all purchased oxygen equipment prior to initial start-up.

The Construction Department is responsible for preparation of the oxygen compressor and associated equipment for initial operation plus basic mechanical checks. Technical direction during this phase shall be the responsibility of Engineering or Operations Department specialists, as required.

For APCI owned plants, the Operations Department is responsible for all oxygen compressor performance testing and inspections following the basic mechanical checks performed by the Construction Department. Technical direction shall be the responsibility of the Engineering Department.

Performance testing and inspections of sale plant oxygen compressors, when required by contract, shall be the responsibility of the Start-up Group. Technical direction shall be the responsibility of Engineering Department Specialists, as required.

IV. PREPARATION FOR INITIAL OPERATION & MECHANICAL CHECKS

A. APCI Owned Plants

Each activity of the Construction Check Sheet (Figure 1) shall be initialed by the performing construction supervisor, dated when each activity was performed, and one copy each supplied to the Project Manager and to the Operations Department Manager of Maintenance and Mechanical Engineering, prior to compressor performance testing by that Department.

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550 MACHINERY

FIELD TESTING

RECIPROCATING OXYGEN COMPRESSOR

B. Sale Plants

Each activity of the Construction Check Sheet (Figure 1) shall be co-initialed by the performing APCI advisor and the owner's representative, dated when each activity was performed and one copy each supplied to the Project Manager and to the performing Start-up Supervisor. The Project Manager shall forward an official copy to the owner.

V. TESTING AND INSPECTION

Prior to operation on line, all new, modified, or overhauled compressors, under APCI responsibility, shall be tested and inspected.

A. APCI Owned Plants

Each activity of the Operations Check Sheet (Figure 2) shall be initialed by the performing Operations Department Supervisor, dated when each activity was performed, and one copy each supplied to the Project Manager and to the Operations Department Manager of Maintenance and Mechanical Engineering.

B. Sale Plants

Each activity of the Operations Check Sheet (Figure 2) shall be initialed by the performing Start-up Supervisor, dated when each activity was performed and one copy each supplied to the Project Manager and Start-up Group Manager. The Project Manager shall forward an official copy to the owner.

DESIGN ENGINEERING STANDARDS 550 MACHINERY

REC	IPRO(CATIN	G OXYGEN COMP	RESSORS	PROJECT PLANT LOCA	TION	
I.	Pre	parat	ion for Initi	al Operation		Supervisor	Date
	Α.	sand	and other re	rea for cleanliness. Assidual construction res m compressor area		-	
	В.	pipi	ng for rust a	interstage, and nitroge nd particles. Reclean and particle free cond	if		Agency (Speech Stage age) by since home
	C.	unda		strainer and verify it with methylene chlorid and install.			
	D.		k that correctalled.	t inlet relief valve is			
	E.	alig cons chec	nment reading truction stag	fits, clearances and staken by erector during and perform all prested by compressor manufactoring:	art-up		
		1.	Remove crank	case inspection covers.			
		2.	Check comple locking devi	teness of bolting and ces.			
		3.	Thoroughly c	lean interior of crankc	ase.		
		4.	Add fluoresc 0.1% by weig Texaco Regal is Oil Color	l reservoir to correct tent dye as required to the (1\frac{1}{4} fluid oz. dye/10 R&O) in the oil Approx #131 Superconcentrate Morton Chemical Co. Div. of Morton Internation 335 McLean Boulevard Paterson, New Jersey	achieve gal. ved dye as	ac.	
		5,	pressure. S	lube oil pump to estable et automatic oil pressure.			
		6,		crankshaft bearing, coring, and crosshead shoesflow.			
			FIGUR			et 1 of 6	Date
Δ	Air	Produc	ts and Chemicals	All information hereon is the confide Chemicals, Inc., unless another source mand and must not be disclosed or repre	is shown, is subje	ct to return on de-	2/3/71

RECIPROC	CATING OXYGEN COMPRESSORS	PROJECT PLANT LOCATION	
		Supervisor	Date
7.	Inspect complete lube oil system for leaks and purge air from oil filter(s).		
8,	Continue to operate pre-lube pump and bar compressor through one revolution.		
9,	Replace crankcase inspection covers.		
10.	Remove all stage valves.	 -	
	a. Inspect chambers for cleanliness with white light and black light.	th	
	b. Bar over compressor and check clears between piston and cylinder heads with piston in extreme positions.		
11.	Check piston to cylinder clearance, if possible.		
12.	Check valves for cleanliness with white light and black light.	*** **********************************	**********
13.	Replace valves in first stage. Double check correct valves are installed in suction and discharge. Replace valve covers on other stages until ready for blowout.		
14.	Inspect piston rods for cleanliness and oil free condition. Use white light and black light for this check. Clean with methylene chloride or trichlorethylene arequired.	đ	-
15.	Determine rod run-out at packing area at two points 90° apart. Check clearance between piston rod and drop detectors.		************
16.	Check motor to compressor alignment or crank web deflection, as applicable.		
17.	Determine that motor rotor is centered diametrically and electrically.		
	FIGURE 1 CONSTRUCTION CHECK SHEET S	Shoat 2 of 6	
	•		Date
J Six 1	Products and Chemicals Chemicals, Inc., unless another source is mand and must not be disclosed or representations.	is shown, is subject to return on de	2/3/71

RECIPRO	CATING OXYGEN COM	PRESSORS	PROJECT PLANT LO	CATION	
				Supervisor	Date
F.	thermostat to mai	on of lube oil heantain 70-80°F. Di ent is above 70°F.	scontinue		
G.		to purge distance iece design. Chec each chamber.		**************************************	-
н.	Check ejector ope for 1-3" H ₂ O cran	eration. Start air kcase vacuum.	flow and set		
I.	coolers and corre	anks have been remet safety discs (pad vacuum support)	ressure,		erioriori, rischesseise
J.	Check that cooling water filled to co	ng tower sump is cl	ean and		
к.	intercooler, after cooler, closed sy packing. Vent en	em and turn on wate ercooler, oil cooler estem water cooler, etrapped air from h eck water flow in a	r, motor cylinders and igh side of		
L.		in at each end of cooler and check fo			
М.		aubber drains and coressor cylinders.	heck for water		
N.		eakage into motor container or drain.	-		
0.	and switches and ice and boiling w	pressor system tem check thermocouple ater. Adjust for ng gages and switc	s in melting accuracy within	ı	
	1. Suction (Hea	t exchanger outlet)		
	2. Outlet, each	stage			
	FIGURE	1 CONSTRUCTION CH	ECK SHEET Shee	t 3 of 6	
} Air	Products and Chemicals	All information hereon is the Chemicals, Inc., unless another mand and must not be disclose	er source is shown, is sub	ect to return on de-	Date 2/3/71

	TING OXYGEN COM		PLANT LOCAT	ION	
			Superviso	r	Date
3	3. Inlet, each	st a ge			
14	. Outlet, afte	ercooler	•		
5	. Water, inlet	t header			
6	. Water, coole	er outlets			
7	'. Lube oil tem	nperature	Marie Cardo		
8	. Valve covers	5			
NO		with sensing bulbs s. Reinstall to fi			
P. Se	t vibration swi	itches on compressor	r frame.		
1	switch adjus light for th	ting compressor bac sting screw until ye hat switch appears o panel. This is zero r switch.	ellow on		
2		w so that yellow lie . Record number of osition.			
3	down circuit	ry jumper wire acros t contacts of switch pressor shutdown du	h to		
14	complete and back off swi yellow light of turns adj position.		rating. w until ine number om zero is number w light		
5	. Remove tempo switch.	orary jumper wire fi	rom		
6	. Set remainde	er of switches in ab	oove	_ .	
	FIGURE 1	CONSTRUCTION CHECK	(SHEET Sheet 4 or	f 6	
	=======================================		confidential property of Air	Products and	Date

RECIPROCATING OXYGE		PROJECT PLANT LOCATION	
		Supervisor	Date
	ollowing automatic valves for fter establishing instrument a		
l. Dischar	rge and interstage vent valves		
pos De 1	th manual 'on-off' switch in 'sition, push control valve restermine that valves are in closition.	et.	
pos	rn manual 'on-off' switch to 'sition. Determine that valves open position.		
2. Suction	n Control Valve and Recycle Va	lve.	
tir to Ad, to De	t flow controls on 'manual'. me delay relay to energize sol suction control and recycle v just air set for suction contr open and for recycle valve to termine that valves go to corr sition.	ralves. col valve close.	
to De	just air set for suction control close and for recycle valve t termine that valves go to corn sition.	o open.	
	move jumper and observe valves llowing position.	s for	
	Suction control valve - closed Recycle Velve - open	1	
NOTE:	Suction control and recycle of determine that they are actual indicators so indicate. Adjust required for correct seats	ally seating when extensions and/or indi	ermal
II. Mechanical Chec	ks		
A. Perform pre	start-up checks per Appendix	I	
B. Blow out in free nitrog	terstage piping using dry, oilen or air.	1	
FIGURE	1 CONSTRUCTION CHECK SHEET	Sheet 5 of 6	
Air Products and Chom	All information hereon is the confidenticals Chemicals, Inc., unless another source is	ial property of Air Products and shown, is subject to return on de-	2/3/71

			Supervisor	Date
	1.	Remove all stage valves and cover for first stage. Suitably cover to cylinder so that foreign materials will be blown to atmosphere.	r entrance ter from	
	2.	Start compressor per steps A. the Appendix II. Purge through 2nd port for 5 minutes.		
	3.	Stop compressor, vacuum clean al valve port areas, install 2nd-s repeat operation.		
	4.	Continue progressively to blow stage until all stage piping is		
c.	rur fac ins	art compressor per Appendix II and in-in conditions specified by compacturer. Shut down after 5 minutes spection covers and feel each bear lication of overheating. Correct replace covers.	ressor manu- s, remove ring for	
D.	ope at per dry	tinue to run-in compressor untileration is accumulated with at least maximum operating conditions. Defined blow out product delivery ling, oil free nitrogen at high velocoty ft/sec).	ast 2 hours uring this ne using	
D.	ope at per dry (20	eration is accumulated with at lease maximum operating conditions. Desired blow out product delivery ling, oil free nitrogen at high velocities.	ast 2 hours uring this ne using	
	ope at per dry (20	eration is accumulated with at lead maximum operating conditions. Desired blow out product delivery ling, oil free nitrogen at high velocities.	ast 2 hours uring this ne using	
	ope at per dry (20	eration is accumulated with at lease maximum operating conditions. Desired blow out product delivery line, oil free nitrogen at high velocity of ft/sec).	ast 2 hours uring this ne using	
	ope at per dry (20	eration is accumulated with at lease maximum operating conditions. Desired blow out product delivery line, oil free nitrogen at high velocity of the product	ast 2 hours uring this ne using	
	ope at per dry (20	eration is accumulated with at lease maximum operating conditions. Described blow out product delivery like, oil free nitrogen at high velocity of the constant of the constan	ast 2 hours uring this ne using city	
	ope at per dry (20	eration is accumulated with at lead maximum operating conditions. Do riod blow out product delivery line, oil free nitrogen at high velocity of the conditions. Remove valves and inspect for: a. Cylinder scoring b. Damage to valves	ast 2 hours uring this ne using city	
	ope at per dry (20	eration is accumulated with at lear maximum operating conditions. Divide blow out product delivery line, oil free nitrogen at high velocity of t/sec). Spections Remove valves and inspect for: a. Cylinder scoring b. Damage to valves c. Piston to cylinder clearance	ast 2 hours uring this ne using city	
	operat per dry (20 Ins	eration is accumulated with at lease maximum operating conditions. Described blow out product delivery line, oil free nitrogen at high velocity of the constant of the constan	ast 2 hours uring this ne using city pect for	

RECIPROCATING OXIGEN CONFRESSORS			PROJECT PLANT L	ANT LOCATION		
					Supervisor	Date
I.	Tes	t on Nitrogen				
	A.	Perform pre start	-up checks per Appendix I.	٠.		
	В.	Observe all opera malfunction and o two hours of sati	on nitrogen per Appendix I ting conditions for signs orrect as required. After sfactory operation at maxi ons. proceed with test on	of		
II.	Tes	t on Oxygen				
	Α.	oxygen for four his not running. suction butterfly	and its piping with 100% ours minimum while compresuse bypass valve around valve for this purpose. The mear ambient temperature by			
	в.	Perform pre start	-up checks per Appendix I.	•		
	C.	with Appendix II. manifold vent. S adjust nitrogen f gen mixture and 7 pressure Correc pressures shall b	on nitrogen in accordance Close rod packing blowby lowly introduce oxygen and eed to achieve a 10-20% ox 5% normal maximum discharge t suction and discharge e determined by Machinery to starting this test. hours.	i cy–		
	D.	Gradually increas 100% over a two h normal maximum di test for one hour	e oxygen concentration to our period. Maintain 75% scharge pressure. Continu minimum after reaching 10 Log following data every)O%		
		1. Stage pressu	res			
		2. Stage temper	atures	•		
		3. Valve cover	temperatures			
		4. Bearing temp	eratures			
		5. Oil pressure	s			
		6. Oil temperat	ures	_		
		FIGURE 2	OPERATIONS CHECK SHEET S	heet 1	of 2	
A	Air	Froducts and Chemicals	All information hereon is the confidential Chemicals, inc., unless another source is s	hown, is subj	f Air Products and act to return on de-	2/3/71

550 MACHINERY

RE	ECIPR	OCATI	NG OXYGEN COMPRESSORS	PROJECT PLANT LOCATION	
				Supervisor	Date
		7.	Water temperatures		
		8.	Oxygen content at aftercooler		
		9.	Oxygen content from distance piece vent*		
		10.	Crankcase vacuum		
		11.	Oil drainage from distance piece*		
		12.	Motor winding temperature		
		13.	Motor load	· —	
			a. If synchronous motor, adjust fie current for unity power factor.	eld	
			b. Voltage at switchgear (each phas if possible)	e,	
			c. Amps at switchgear (each phase, if possible)		
	Ε.	100%	design conditions and operate for nours minimum. Log above data every inutes at all sensing points.		
II.	Tre	atment	of Cooling Systems		
	Α.	Secti	en compressor closed cooling systems be treated in accordance with on 6.13 of Cryogenic Systems Division Operations Manual.	n	
	B.	Open accor	cooling systems shall be treated in dance with specification 90137A.		
	*If	double	e distance piece design.		
			FIGURE 2 OPERATIONS CHECK SHEET Sh	meet 2 of 2	

Air Products and Chemicals

550 MACHINERY

FIELD TESTING

RECIPROCATING OXYGEN COMPRESSORS

APPENDIX I

Pre start-up Checks

The following pre start-up checks shall be performed prior to each start-up of an oxygen compressor.

- I. Establish cooling water flow
 - A. Open water header inlet and return valves.
 - B. Open valves from intercoolers, aftercooler, motor cooler, cylinders and packing.
 - C. If closed water cooling system is provided:
 - 1. Check level in water tank and add water if necessary
 - 2. Open valves for water cooler.
 - 3. Start water pump.
 - D. Adjust water outlet valve from oil cooler to achieve rapid warm up to minimum operating temperature.
 - E. Purge air from all coolers.
 - F. Check water flow at all water sight glasses.
 - G. Check for water leaks into oxygen piping by opening process drain at each end of intercoolers and aftercooler. Close valve after check is complete.
 - H. Check for water leaks into compressor cylinder by opening each pulsation snubber drain. This will also drain any water carried over to snubbers fr m upstream intercooler leaks.
- II. Set up for Oil Flow
 - A. Check that lube oil reservoir is filled to correct level.
 - B. Turn on oil reservoir heater if ambient is below 70°F.
 - C. Using black light, check piston rod for oil free condition on cylinder side of oil slinger If oil is found on rod, the packing must be disassembled and cleaned and bottom half of cylinder must be inspected through valve ports. If oil is found in bottom half of cylinder, complete piston removal is required.

550 MACHINERY

FIELD TESTING

RECIPROCATING OXYGEN COMPRESSORS

APPENDIX I (Continued)

- D. Establish nitrogen purge to distance piece.*
- E. Establish ejector flow for 1-3" H₂O vacuum on crankcase.
- F. Operate pre-lube oil pump to establish oil pressure. Observe piping, etc. for leaks. Maintain oil pressure and bar compressor through one revolution.
- III. Observe that vibration switch yellow lights are not lighted.

*If double distance piece design.

FIELD TESTING

RECIPROCATING OXYGEN COMPRESSORS

APPENDIX II

Start-up on Nitrogen

- I. Oxygen compressors shall always be started on nitrogen.
- II. The following outline is generally applicable for startup of a single compressor installation and will require modification to suit each particular arrangement of single, series, parallel and mixed compressors. More detailed procedures shall be prepared by the Operations Department to cover each APCI installation or by the Start-up Group to cover sale plants.
 - A. Close product line manual block valve downstream from discharge vent valve.
 - B. Partially open vent valve adjacent to block valve to permit piping purge with nitrogen.
 - C. Open any other line valves between compressor and block valve.
 - Close block valve to adsorber pressurizing circuit, LOX transfer tank, etc. D.
 - Verify that compressor suction manual valve is closed. Ε.
 - F. Crack drain at each snubber bottle.
 - G. Fully open packing blowby manifold vent.
 - H. Push "reset" button at "start-up" station to accomplish the following:
 - 1. Close interstage dump valves.
 - 2. Set discharge dump valve on control.
 - 3. Set up recycle valve and automatic suction valve for control after compressor motor is started and time delay relay has closed.
 - I. Adjust air set on recycle valve for wide open position.
 - J. Adjust air set on suction valve for closed position.
 - Open interstage unloading valves wide. K.
 - Close nitrogen bleed and open nitrogen double block valves to purge L. compressor until oxygen content is less than 5% at aftercooler outlet.
 - M. After compressor is thoroughly purged, close discharge vent valve.
 - N. Starting compressor:
 - 1. Adjust nitrogen feed valve to obtain normal suction pressure.
 - 2. Operate pre-lube oil pump to establish oil pressure.

550 MACHINERY

FIELD TESTING

RECIPROCATING OXYGEN COMPRESSORS

APPENDIX II (Continued)

- 3. Start compressor motor.
- 4. Adjust nitrogen feed rate to maintain normal compressor suction pressure.
- 5. Check oil pressure. If normal or higher than normal, stop pre-lube pump.
- O. Close snubber drain valves.
- P. Adjust interstage unloading valves and recycle valve to obtain manufacturer's recommended minimum stage pressures.
 - NOTE: Labyrinth piston type reciprocating compressors should be loaded to minimum recommended pressures as soon as possible after starting to center the pistons in their cylinders.
- Q. Adjust oil cooler water outlet valve to maintain correct oil temperature to bearings.
- R. Check compressor to determine if all conditions are normal. Log the following data at all sensing points.
 - 1. Stage pressures
 - 2. Process temperatures
 - 3. Valve cover temperatures
 - 4. Oil pressures
 - 5. Oil temperatures
 - 6. Water temperatures
 - 7. Oxygen content at aftercooler
 - 8. Crankcase vacuum
 - 9. Oil drainage from distance piece (If double distance piece design)

NOTE: Observe packing blowby manifold vent. Essentially no graphite (Sulzer compressors) particles should be observed in vent gas if rod packing is correctly installed. Other machines utilizing tight rod packing may exhibit some packing particles. The blowby manifold vent should remain open until ready to introduce oxygen to compressor.

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

I. PURPOSE

This standard establishes requirements for field testing of centrifugal oxygen compressors.

II. SCOPE

This standard applies to all centrifugal oxygen compressors installed or operated by APCI. Therefore, contracts, for sales plants which are erected by the owners with APCI advisors, shall require conformance as stated below in paragraph IV. B.

III. RESPONSIBILITY

Project Engineering shall provide the Operations Department, the Start-up Group and the owner (if different than APCI) with inspection and cleanliness reports on all purchased oxygen equipment prior to initial start-up.

The Construction Department is responsible for preparation of the oxygen compressor and associated equipment for initial operation plus basic mechanical checks. Technical direction during this phase shall be the responsibility of Engineering or Operations Department Specialists, as required.

For APCI owned plants, the Operations Department is responsible for all oxygen compressor testing and inspections following the basic mechanical checks performed by the Construction Department. Technical direction shall be the responsibility of the Engineering Department.

Performance testing and inspections of sale plant oxygen compressors, when required by contract, shall be the responsibility of the Start-up Group. Technical direction shall be the responsibility of Engineering Department Specialists, as required.

IV. PREPARATION FOR INITIAL OPERATION & MECHANICAL CHECKS

A. APCI Owned Plants

Each activity of the Construction Check Sheet (Figure 1) shall be initialed by the performing Construction Supervisor, dated when each activity was performed, and one copy each supplied to the Project Manager and to the Operations Department Manager of Maintenance and Mechanical Engineering.

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

B. Sale Plants

Each activity of the Construction Check Sheet (Figure 1) shall be co-initialed by the performing APCI advisor and the owner's representative, dated when each activity was performed and one copy each supplied to the Project Manager and to the performing Start-up supervisor. The Project Manager shall forward an official copy to the owner.

V. TESTING AND INSPECTION

Prior to operation on line, all new oxygen compressor installations and existing installations under APCI responsibility, which are modified with new design rotors or bearings, shall be tested at partial normal discharge pressure using 100% nitrogen and then at overpressure using an oxygen density mixture of nitrogen and carbon dioxide. Finally, a short test on oxygen is required. Operation on nitrogen is required to determine correct assembly through observation of operating data such as oil temperature, flow, etc. Operation on nitrogen-carbon dioxide mixture is required to determine rotor stability. Operation on oxygen is for final proof test and determination of power input.

A. APCI Owned Plants

Each activity of the Operations Check Sheet (Figure 2) shall be initialed by the performing Operations Department Supervisor, dated when each activity was performed, and one copy each supplied to the Project Manager and to the Operations Department Manager of Maintenance and Mechanical Engineering.

B. Sale Plants

Each activity of the Operations Check Sheet (Figure 2) shall be initialed by the performing Start-up Supervisor, dated when each activity was performed and one copy each supplied to the Project Manager and Start-up Group Manager. The Project Manager shall forward an official copy to the owner.

550 N	MACHINERY
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CEN	TRIF	UGAL OXYGEN COMPRES		OJECT ANT LOCATION	
ı.	Pre	paration for Initia	al Operation	Superviso	r Date
	Α.		rea for cleanliness. All desidual construction residue ompressor area.		
	В.	piping for rust a	interstage and nitrogen pur nd particles. Reclean if and particle free condition		
	С.		strainer and verify if it i tth methylene chloride or and install.	is 	
	D.	length with methyl to remove all trace	ine from each dry sump for eleme chloride or trichlorethes of oil and assure line is, and any other restriction	nyl ene Is	
	Ε.	separately piped	y vents and coupling vents a outside personnel shield to and that they are distant i vents.	a	
	F.	Check that correctinstalled.	t inlet relief valve is		
	G.	coolers and correc	anks have been removed from at safety discs (pressure, t m support) have been install		
	Н.	Check that cooling is filled to corre	g tower sump is clean and we ect level.	ater	
	I.	intercooler, after	m and turn on water to each recoler, oil cooler motore, water cooler. Vent entrapp e of each cooler,		
	J.		in at each end of each inter puler and check for water	r- 	
	К.	-	asing drains and check for vaga cooled machines.	water ————	_
	L.		enkage into motor by observ ontainer or drain.	ving	
		FIGURE 1 CO	NSTRUCTION CHECK SHEET Sines	etlof 6	
A	- Ai	r Products and Chemicals	All information hereon is the confidential p Chemicals, Inc., unless another source is sho	property of Air Products and wn, is subject to return on do	Date 2/3/71

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CENTRIF	TUGAL OXYGEN COMPRESSORS	PROJECT	
		PLANT LOCATION	
		Supervisor	Date
М.	Calibrate all compressor system gages and switches and check to in melting ice and boiling wat for accuracy within 2°F. The gages and switches are to be in	chermocouples cer. Adjust following	
	1. Suction (heat exchanger o	utlet)	
	2. Outlet, each stage		
	3. Inlet, each stage		
	4. Outlet, aftercooler		
	5. Water, inlet header		
	6 . Water, cooler outlets	***************************************	
	7. Lube oil temperature		
		bulbs and thermocouple probes rearmly touch bottom of well.	moved from
N.	green lights are on. If necess (alert) or red (danger) lights then away from shaft to determ indicating integrity of circuit	d axial position monitors. Check sary, press reset button to turn a. Adjust each probe closer to since if green lights go out each stry. Set each probe to obtain condits voltage on proximeter using	n off yellow haft and time, thus correct gap
	NOTE: Green light may not go position during shutdown	on for axial vibration probe due	to shaft
	The following probes are to be operation.	e connected to the monitor for con	mpressor
	Location	Reading	
	Compressor outboard end	Axial position Axial vibration Vertical vibration	
	Compressor inboard end	Vertical vibration	
	High speed pinion*	Vertical vibration	
	*If gear arrangement permits p	robe installation.	
	FIGURE 1 CONSTRUCTION CHE	ECK SHEET Sheet 2 of 6	
	All information her	reon is the confidential property of Air Products and	Date

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CENTRI	FUGAL OXYGEN COMPRI	r LOCATION				
The fo	ollowing probes are uired.	not to be co	nnected t	o monitor	except for	periodic checks
					Supervisor	r <u>Date</u>
	Location		Reading			
	Compressor outboar	d end Hori	zontal vi	bration		
	Compressor inboard	l end Hori	zontal vi	bration		
	High speed pinion		l positic l vibrati			-
0.	Establish seal gas valve and adjust p pressure specified	ressure regui	lating va	lves at		
	1. Check panel ga	ges for corre	ect press	ure.		
	2. Red line gages values.	for alarm a	nd shutdo	wn		-
P.	Open back-up seal certain cylinder pack-up seal gas paccorrect pressure. seal gas and determaintains correct	ressure is accressure regularity mine that bac	dequate. lator for shut off ck-up sys	Adjust regular tem	****	
Q.	Check all casing p	orts for prop	p er venti	ng.		
R.	Inspect casing iso oil and clean with necessary. Vacuum isolation ports wh	methylene chany dirt out	nloride i t of vert	f ical		
s.	Check that lube oi level. Add oil if		is at cor	rect		
T.	Check out operation thermostat to main operation if ambie is complete.	tain 70-80°F.	. Discon	tinue		
υ.	With seal gas flow Set automatic oil correct pressure.		-			•
	*If gear arrangeme	nt permits pi	robe inst	allation.		
	FIGURE 1 CONS	TRUCTION CHEC	CK SHEET	Sheet 3 c	of 6	
A Al	ir Products and Chemicals	All information here Chemicals, Inc., unle mand and must not be	ess another sou	rce is shown, is s	ubject to return on	de- 2/3/71

CENTRI	FUGAL	OXYGE	N COMPRE	SSORS		ROJECT LANT LOC	ATION	
						<u>2</u>	Supervisor	Date
٧.	Inspe	ect lu	be oil s	system.				
	1.	syste isola	m for le	eaks. After cts and dry s	inspect comp 15 minutes ch ump drain for	eck		
	NOTE				il from the d il is accepta			
	2.	verif that	y that a all noza	all gears are	rom speed inc being oil sp ative. If sa on cover.	rayed ar		
	3.	that and t coupl be ce coupl	coupling that all ing spacertain of ing and	g teeth are be nozzles are cer both dire il spray tube are directed	ng guard and eing oil spra operative. P ctions with b s do not hit properly for ing position.	yed Push par to		
₩.		gas o			own switches at correct p			
	1.	Close		valve for bac	k-up seal gas	; -		0
	2.	syste	em to red ich swite		ain seal gas to alarm lev ential switch			
	NOTE				l be required t occur simul			t
	CAUT	ION:	be allow possible	wed to drop t	ports closes o zero and sh orming these t	ould be	maintained	as high as
	3.			ach switch op that alarm s	ens at correctounds.	et		
		press shut	sure to I d own a ux	just main sea lower values xiliary oil p TION CHECK SH	required to ump.	• of 6		
A	ir Produ	cts and l	Kemicals	Chemicals, Inc., unl	reen is the confidential less another source is to be disclosed or reprodu	shown, is sub	ject te return en de-	2/3/71

ODIVITALI COME CHICARI COME CONTROL CO	PROJECT PLANT LOCATION		
	Supervisor Date		
 Check that each switch opens at correct pressure and that auxiliary oil pump stops. 			
X. Check the following automatic valves for corre operation after establishing instrument air pressure.	ect		
1. Discharge vent valve.			
a. With manual 'on-off' switch in 'off' position, push control valve reset. Determine that valve is in closed position.			
b. Turn manual 'on-off' switch to 'on' position. Determine that valve is in open position.	n		
2. Suction control valve and recycle valve.			
a. Set flow controls on 'manual'. Jumpe time delay relay to energize solenoid to suction control and recycle valves Adjust air set for suction control valve to open and for recycle valve close. Determine that valves go to correct position.	ds s.		
b. Adjust air set for suction control verto close and for recycle valve to open Determine that valves go to correct position.			
c. Remove jumper and observe valves for following position.			
Suction Control Valve - Closed			
Recycle Valve - Open			
NOTE: Suction control and recycle valve that they are actually seating whe indicate. Adjust stroke and/or is correct seating.			
FIGURE 1 CONSTRUCTION CHECK SHEET Sh	eet 5 of 6		
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CENTRIF	FUGA]	L OXYGEN	1 C	OMPRESSORS		PROJECT PLANT LOCATION			
							Supervisor	<u>Date</u>	
II.	Mecl	nanical	Ch	ecks					
	A.	Perform	n p	re start-up check	s per Appen	dix I.			
	В.	and oper pressur by Mack condition as required	eral re a ninci ion: uire ry	pressor on nitrogete for four hours achievable on nitery Engineering. In for signs of masted. During this line using dry, ocity (200 ft/sec)	at maximum rogen as de Observe all Ifunction apperiod, blow il free nit	discharge termined l operatin nd correct w out prod	g		
	С.	drive to compress temperal NOTE: A	ra: sso: atu: Acci	and check alignments. If adjustments on nitrogen at a curacy of this alignments the check is cuitations apply.	t is necessa hieve maxim nd recheck a gnment check	ary, repeat um operati alignment. « depends	ng on temperature		
		1	L .	Ambient should be Temporary shelter ambients during a	rs must be w	util ize d t	o achieve thes		
		2	2.	Alignment check and otherwise, additional achieve a stability	ional warmu	periods			

FIGURE 1 CONSTRUCTION CHECK SHEET Sheet 6 of 6

550 MACHINERY

CENT	RIFU	GAL C	XYGE	N COMPRESS	ORS	PROJECT PLANT I	LOCATION —	
							Supervisor	Date
I.	Test	t on	Nitr	ogen				:
	Α.	Perf	`orm	pre start-	up checks per Append	dix I.		
	В.	Obse malf two	erve Cunct hour	all operation and cost of satis	n nitrogen per Apper ing conditions for s rrect as required. factory operation, p gen-carbon dioxide n	signs of After preceed		
II.	Test	t on	Nitr	ogen - Car	bon Dioxide Mixture			
	will prog from	l spe gress m max	cify sivel	the opera y overpres normal to	compressor, Machiner ting conditions requ sure test in increme 125% (or higher if harge pressure.	uired to ents of 5%	3	
		CAUT	'ION:	intercon	maximum operating prected equipment; cocompressor cases, et ng these test condit	oolers, relief tc. when		
	Α.			Figure 3 ment for th	for material and equis test.	u ipme nt		
	В.	cart	oon d	mpressor op dioxide to bon dioxide	perating on nitrogen achieve a 75% nitrogen mixture.	, introduce gen and		
	C.	sufi	ficie	ent time fo	r at each pressure lear temperatures to see data at all sensing	tabilize.		
		1.	Vib	ration leve	els (by tape) at:			
			a.	Running sy	need of compressor			
			b.	One-half	running speed of com	pressor		
			c.	First crit	cical speed as defin	ed by		
			d.	First critindependent	tical speed as defin nt consultant (if di e)	ned by fferent		
				FIGURE 2	OPERATIONS CHECK S	SHEET Sheet 1	of 4	
A	T A	ir Proc	lucts a	d Chomicals	All information hereon is the c Chemicals, Inc., unless another	confidential property o source is shown, is sub	f Air Products and ject to return on do-	2/3/71

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CENTRIFUGAL OXYGEN COMPRI		ROJECT	
		Supervisor	Date
e. Twice r	unning speed of compressor		
	imes running speed of		
compress			
2. Bearing temp	peratures		
3. Oil pressure	es		
4. Oil temperat	tures		
5. Process pres	ssures	-	
6. Process temp	peratures		
7. Water temper	ratures		
to check venting	sure test is completed proceeding time for dump valve using to a carbon dioxide mixture.		
	ressor for design suction and ressures and operate on total		
stop compres Determine an	ssor operating as in 1, above, ssor by actuating panic button and record time required for ressure to vent to 15 psig.		
III. Inspections			
	ompressor case and inspect int s*, labyrinth clearances and s		
B. Remove suction cleanliness* an	strainer and inspect for ad punctures.		-
C. Reassemble comp	pressor and strainer.		-
IV. Test on Oxygen			
	performed after successful en-carbon dioxide mixture is		
* Perform cleanliness	inspections with white light a	and black light.	
FIGURE 2 OPE	ERATIONS CHECK SHEET Sheet 2	of 4	
Air Products and Chemicals	All information hereon is the confidential pro Chemicals, inc., unless another source is shown mand and must not be disclosed or reproduced wi	, is subject to return on de-	2/3/71

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CENTRIFUGAL OXYGE	T LOCATION —				
			Supervisor	Date	
for four running fly va l	ompressor and its piping with 100% or hours minimum while compressor is . Use bypass valve around suction to ve for this purpose. Compressor to temperature before starting purge.	not butter- be nea:			
P. Perform	pre start-up checks per Appendix I.	•			
Appendi: nitroge	ompressor on nitrogen in accordance x II. Slowly introduce oxygen and a n feed to achieve a 10 - 20% oxygen normal maximum discharge pressure.	adjust	•		
NOTE:	Correct suction and discharge pressum Machinery Engineering prior to start	ures sha ting th	all be deter is test.	mined by	
over a maximum one house concent.	D. Gradually increase oxygen concentration to 100% over a two hour period. Maintain 75% normal maximum discharge pressure. Continue test for one hour minimum after reaching 100% 02 concentration. Log following data every 30 minutes at all sensing points.				
1. Vib	ration levels (by tape) at:				
a.	Running speed of compressor	,			
b.	One-half running speed of compress	or			
с.	First critical speed as defined by manufacturer				
d.	First critical speed as defined by independent consultant (if differentian above)	nt			
e.	Twice running speed of compressor				
f.	Three times running speed of compressor				
2. Bea	ring temperatures				
3. Oil	pressures				
	FIGURE 2 OPERATIONS CHECK SHEET	Sheet 3	3 of 4		
A	All information hereon is the confidential	property o	of Air Products and	Date C. (C. (C.)	

ODMINE CONTROL OF THE	PROJECT PLANT LOCATION		
	Supervisor	Date	
4. Oil temperatures			
5. Water temperatures	<u> </u>		
6. Process temperatures			
7. Process pressures			
8. Motor winding temperature			
9. Motor load			
a. If synchronous motor, adjust field current for unity power factor.			
b. Voltage at switchgear (each phase, possible)	if		
c. Amps at switchgear (each phase, if possible)	**************************************		
E. Increase flow and discharge pressure to 100 design conditions and operate for two hours minimum. Log above data every 30 minutes at all sensing points.	8		
V. Treatment of Cooling Systems			
A. Oxygen compressor closed cooling systems streated in accordance with Section 6.13 of Cryogenic Systems Division Plant Operations Manual.			
B. Open cooling systems shall be treated in accordance with specification 90137A.			
FIGURE 2 OPERATIONS CHECK SHEET S	Sheet 4 of 4		
All information hereon is the confidential	property of Air Products and	Date	

CENTRIFUGAL OXYGEN COMPRESSORS

I. Gas Mixture

A. Nitrogen: 75%

B. Carbon Dioxide: 25%

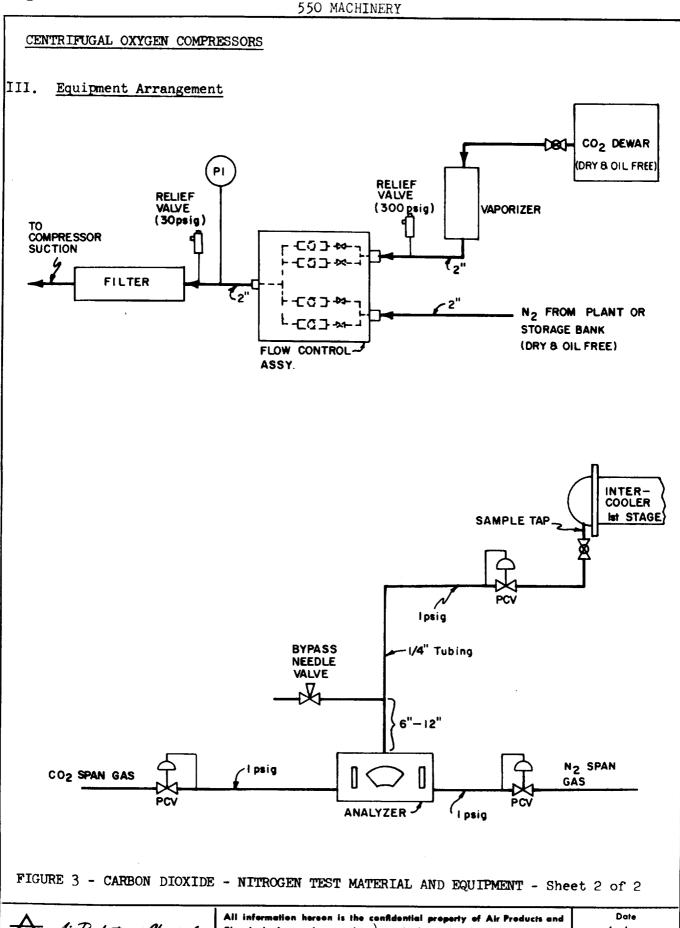
NOTE: These gases must be dry and oil free.

II. Equipment

- A. Flow Control Assy. APCI Dwg. 0-1150-12-6C
- B. Filter Pall Trinity Micro Corp. #MES-1012-RJ49
- C. CO₂ Vaporizer 340 Ft² area, 300 psig
- D. Relief Valves 300 psig 30 psig
- E. Pressure Gage 0-30 psig
- F. Analyzer Thermal conductivity, Gowmac Model #20-100
- G. Pressure Regulator (3) required for controlling pressure into analyzer at 1 psig
- H. Nitrogen Span Gas
- I. Carbon Dioxide Span Gas
- J. Vibration Equipment
 - * 1. Proximeters As required for probes not normally connected to permanent proximeters.
 - * 2. Proximeter Power supply For first critical monitor
 - * 3. Dual Trace Oscilloscope & Camera
 - * 4. Wobulator Signal Generator
 - * 5. Frequency Filters, Variable
 - * 6. Tape Recorder (4 channel Sony F.M.)
 - 7. Power Supply Cables, 10 ft.
 - 8. Coaxial Cables, 150 ft.

*Supplied by Bentley Nevada

FIGURE 3 - CARBON DIOXIDE - NITROGEN TEST MATERIAL AND EQUIPMENT Sheet 1 of 2



DESIGN ENGINEERING STANDARDS

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

APPENDIX I

Pre start-up Check

The following pre start-up checks shall be performed prior to each start-up of an oxygen compressor.

- I. Establish seal gas flow.
 - A. Open seal gas block valve.
 - B. Check pressure control valves for correct setting.
 - C. Check panel gages for correct pressure.
 - D. Check casing vents for proper venting.
 - E. Verify that back-up nitrogen bottles are full. Open nitrogen supply valves and check for correct pressure control valve setting.
- II. Check that lube oil reservoir is filled to correct level
- TII. Establish oil flow.
 - A. Start auxiliary oil pump
 - B. Turn on reservoir heater if ambient is below 70°F
 - C. Check oil pressure for correct value.
 - D. Check oil sight glasses for correct flow.
 - E. After 15 minutes, check isolation ports and dry sump drains for signs of oil.
 - IV. Establish cooling water flow.
 - A. Open water header inlet and return valves.
 - B. Open valves from intercoolers aftercooler and motor cooler.
 - C. If diaphragm cooling system is provided:
 - 1, Check level in water tank and add water if necessary.
 - 2. Open water valves for diaphragm water cooler.
 - 3. Start water pump.
 - 4. Check for water leakage at diaphragm manifold on compressor.

DESIGN ENGINEERING STANDARDS

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

APPENDIX I (Continued)

- D. Adjust water outlet valve from oil cooler to achieve rapid oil warm up to minimum operating temperature.
- E. Purge air from all coolers.
- F. Check for water leaks into oxygen piping by opening process drain at each end of intercoolers and aftercooler. Close valves after check is complete.
- V. Establish vibration and axial position monitor operation.
 - A. Turn power on at least 10 minutes before starting compressor.
 - B. Check that by-pass circuits are not actuated.
 - C. Check that all green lights are on. Green light for axial vibration may not be on if shaft is in extreme position.
 - D. If necessary, turn off alert (yellow) or danger (red) lights by actuating reset button.

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

APPENDIX II

Start-up on Nitrogen

- I. Oxygen compressors shall always be started on nitrogen. Except in extreme emergencies or when testing on nitrogen-carbon dioxide mixture, they shall always be stopped on nitrogen. Prior to operating on nitrogen, the correct operating conditions required to avoid surge shall be determined by Machinery Engineering. Operation on nitrogen must be with automatic recycle valve on manual operation.
- II. The following outline is generally applicable for startup of centrifugal compressor installations and will require adjustment to suit each particular arrangement. More detailed procedures shall be prepared by the Operations Department to cover each APCI installation or by the Start-up Group to cover sale plants.
 - A. Close product line manual block valve downstream from manual discharge vent.
 - B. Partially open vent valve adjacent to block valve to permit piping purge with nitrogen.
 - C. Open any other line valves between compressor and block valve.
 - D. Close compressor suction manual valve.
 - E. Close block valve in adsorber pressurizing and LOX transfer tank circuits.
 - F. Set compressor flow controls on manual and adjust air sets for valves at the following positions:

Suction Control Valve - Closed

Recycle Valve - Open

- G. Push "reset" button at "start-stop" station. This step closes the discharge vent valve immediately and sets up the suction control and recycle valves for control after compressor motor is started and time delay relay has closed.
- H. Close nitrogen bleed and open nitrogen double block valves to purge compressor until oxygen content is less than 5% at aftercooler outlet.

NOTE: Maintain compressor suction side pressure well below suction relief valve setting.

I. After compressor system is thoroughly purged, close manual discharge vent.

550 MACHINERY

FIELD TESTING

CENTRIFUGAL OXYGEN COMPRESSORS

APPENDIX II (Continued)

- J. Starting compressor:
 - 1. Adjust nitrogen feed valve to obtain 10 psig at compressor suction.
 - 2. Push compressor start button. NOTE: Temporarily by-pass vibration monitor shutdown circuit until compressor is at full speed.
 - Adjust nitrogen feed rate to maintain 1-2 psig at compressor suction.
- K. Stop auxiliary oil pump. Set auxiliary oil pump switch to "auto" position.
- L. Check compressor to determine if all conditions are normal. Log the following data at all sensing points.
 - Vibration levels
 - Bearing temperatures
 - 3. Oil pressures
 - 4. Oil temperatures
 - 5. Water temperatures
 - 6. Process temperatures
 - 7. Process pressures
 - Oxygen content at aftercooler
- M. If all conditions are satisfactory, throttle recycle valve to raise discharge pressure to 50% of normal pressure achievable on nitrogen. Again check and log all conditions and, if satisfactory, operate at this level for one hour minimum. Raise discharge pressure in 25% increments by throttling recycle valve. Operate for one hour minimum at each level and log conditions. If satisfactory conditions exist at each level, continue until maximum predetermined pressure is reached.
 - NOTE: If compressor has previously been run-in at reduced discharge pressure, proceed immediately to the maximum predetermined pressure.

OXYGEN PIPING

I. PURPOSE

To establish the basic rules for the design of gaseous oxygen piping systems.

II. SCOPE

This standard defines the requirements for all gaseous oxygen piping systems designed, installed, or operated by APCI.

III. RESPONSIBILITY

Conformance to this standard is the responsibility of APCI Design Engineering Any deviations shall be approved by the Manager of Design Engineering. Director of Safety, and Director of Engineering Design Policy.

IV. DESIGN CRITERIA

All oxygen piping shall be designed and installed in accordance with ANSI B31.3, "Petroleum Refinery Piping" (latest edition) and the following supplemental rules.

- A. Several observations have been made from a study of the past history of fires in oxygen service.
 - 1. There has been no indication of ignition occurring in clean carbon steel or stainless steel systems sized for normal pressure drop unless precipitated by the introduction of a foreign substance.
 - 2. There have been several instances where ignition was indicated in carbon steel and stainlesss steel systems operating at, or near, sonic velocity. Friction from high-velocity particles is considered to be the source of ignition.
 - 3. Copper, brass, and nickel alloys have the characteristic of melting at temperatures below their ignition temperature. This characteristic makes them extremely resistant to ignition in oxygen service. Once ignited, these materials exhibit a much slower rate of burning than carbon or stainless steels.
- B. Considering the above observation and review of published reports* leads to the following basic design rules:
 - 1. Use of carbon or stainless steel piping in continuous or frequent flow circuits must be limited to velocity well below sonic. The maximum velocity for these materials has been established at 200 ft/sec to provide a significant margin below sonic and an economical limit for pressure drop.

*See Bibliography



OXYGEN PIPING

av. B. (Concluded)

2. Lines with velocities greater than 200 ft/sec shall be constructed of copper, brass, or nickel alloys.

Exempted from this requirement are vent lines to the extent permitted by figures 1, 2, 3 and 4. Additionally, pressure letdown systems with inlet pressure equal or less than 15 psig and/or downstream pressures above 90% of upstream pressure, based on normal operating differential pressures, or 80%, based on maximum operating differential pressures, are exempt as shown by figure 7.

- 3. Valves and piping continuously exposed internally to moist gas (dew point above -40°F) or atmospheric air shall be constructed of a non-corrosive material such as bronze, copper, brass, nickel alloys or stainless steel.
- 4. The 300 Series stainless steels have a higher ignition temperature and are less susceptible to corrosion than the 400 Series stainless steels. Therefore, when operating conditions require use of stainless steel, it shall be the 300 Series.
- 5. Cleanliness is a prime requisite of all oxygen piping as well as nitrogen piping used for purging oxygen systems. Cost of achieving and maintaining cleanliness shall be considered in selecting the best materials. Therefore, stainless steel will normally be utilized in place of carbon steel for oxygen compressor interstage piping, discharge piping to the check valve and recycle piping to the throttle control valve, where operating pressures permit the use of schedule 10. Required cleanliness is to be achieved by the following:

a. Welding

- (1) Backup rings shall <u>not</u> be used except for piping within a cold box up to and including the first flange outside the cold box.
- (2) First root pass shall be with inert gas shielded arc process (TIG or MIG).
- (3) Unless interior of each weld joint can be visually inspected, X-ray is required to verify absence of potentially loose metal. All field closure joints shall be X-rayed for this determination as well as for joint integrity.

b. Cleaning

(1) Cleaning procedure shall be used which will achieve the Class AA level as defined by QCL 101F. Acceptable procedures are defined in Construction Specification 200. Prior to plant start-up, oxygen compressor piping and nitrogen purge piping shall be inspected for cleanliness in accordance with repuirements of APCI Standards 551.8.1 and 552.8.1.

OXYGEN PIPING

IV. (Continued)

- C. Design Detail
 - 1. Oxygen process pipe sizes shall be specified by the process engineer and shall normally be based on an economic pressure drop. Each line shall be checked by the process engineer and the piping engineer to verify that the velocity in the normal pipe (as opposed to valving etc.) does not exceed 200 ft. per second.

Oxygen vent, recycle and pressure letdown pipe sizes shall also be specified by the process engineer based on maximum flow through the throttle valve at maximum ΔP conditions.

- 2. Certain areas in oxygen piping systems require special attention because the velocity is known to approach sonic velocity. Some of these areas are specified below.
 - Note: 1. All pressures stated herein are maximum operating unless otherwise noted.
 - 2. Piping materials indicated in figures as carbon or stainless steel may be copper alloy if permitted by design pressures.
 - 3. High velocities may cause vibration adjacent to throttle valves. Adequate material thickness must be selected to withstand this effect.
 - 4. Valve trim shall conform to the material selection shown for valves in the figures. Throttle valve wear or seating surfaces may be faced with Colmonoy #5 or 6.

a. Vent Systems

Vent locations and elevations shall comply with standard 570.8

Adequate supports shall be provided where required for the thrust of vent systems.

The entire system downstream of the valve shall be of non-corrosive material because it is continuously exposed to the atmosphere.

- Pressure control vent systems, inlet pressure > 15 psig.
 See figure 1.
- (2) Pressure control vent and compressor dump systems, inlet pressure ≤ 15 psig. See figure 2.
- (3) Compressor dump systems, inlet pressure > 15 psig. See figure 3.
- (4) Relief valves, all pressures. See figure 4.

OXYGEN PIPING

IV. C. 2. a. (Concinued)

- (5) Typical indoor arrangement. See figure 5.
- b. Pressure Letdown Systems
 - (1) Systems with upstream pressure (P_1) above 15 psig and downstream pressure $(P_3) < 90\%$ P_1 , based on normal operating differential pressures or $P_3 < 80\%$, based on maximum operating differential pressures. See figure 6.

This system will be used for such applications as
(a) letdown from storage pressure to line pressure and
(b) letdown for reduced pressure requirements in multiple
user systems. Such systems will often produce near
sonic velocities at the control valve discharge.

(2) Systems with upstream pressure (P_1) equal to or below 15 psig and/or downstream pressure $(P_3) > 90\% P_1$, based on normal operating differential pressures or $P_3 > 80\% P_1$, based on maximum operating differential pressures. See figure 7.

These systems are simplified on basis of economics and reduced exposure.

c. Compressor Recycle System. See figure 8.

This system is particularly critical because of the high flow rate, the conditions under which it is operated, and the potential damage from a fire in this area. The side entrance tee is considered a vulnerable area due to possible direct impingement of high velocity particles. Therefore, the following impingement surfaces shall be provided.

- (1) Line sizes 6" and below Use Monel tee.
- (2) Line sizes 8" and above The inside of the run of the tee shall be lined with an impingement plate located as shown in figure 8. Impingement plate shall be 1/16-inch-thick, rolled Monel, ASTM Bl27. The length shall exceed the branch inside diameter by an equal distance "x" on each side in accordance with the following schedule:

Sizes

"x" Dimension

8" - 10"

2"

12" & larger

3"

This limitation is required to provide a l' minimum distance from edge of plate to end of tee to minimize warping.

OXYGEN PIPING

IV. C. 2. c. (Continued)

The plate shall cover one-half of the pipe circumference in the main run and shall fit tightly and continuously against the inner wall. Attachment shall be by continuous TIG weld along all edges to achieve a smooth bead. Potentially loose material or sharp edges are not permitted.

3. Orifice plate material shall be Monel for velocities greater than 200 ft/sec through the orifice and stainless steel for lower velocities.

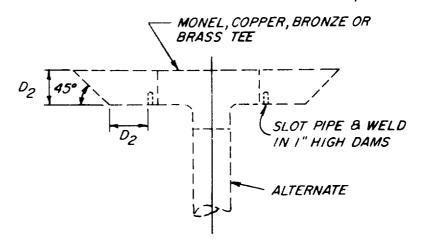
OXYGEN PIPING

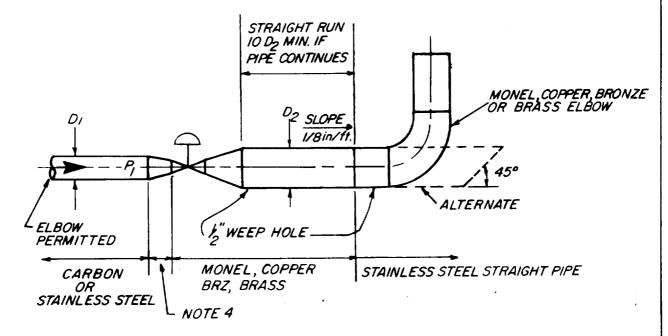
Bibliography

- 1. "Ignition Characteristics of Metals and Alloys," by L. E. Dean and W. R. Thompson, Aerojet General Corp.
- 2. "Ignition of Metals in Oxygen," Battelle Memorial Institute.
- 3. "Safety in Oxygen Piping Systems," by L. deJessey, Societe L'Air Liquide Paris.
- 4. "Comments on Mr. L. deJessey's Oxygen Pipeline Paper," by R. L. Knight, Union Carbide Corp., Linde Division.

OXYGEN PIPING

D₁ - SIZE AT V = 200 FPS D₂ - ONE FULL LINE SIZE 2 GREATER THAN D₁





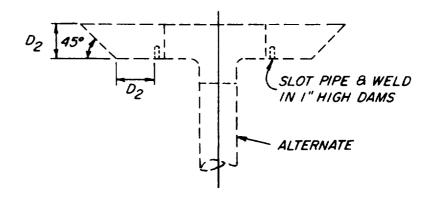
NOTE: 1. See standard 570.8 for design criteria for exclusion of rain or snow.

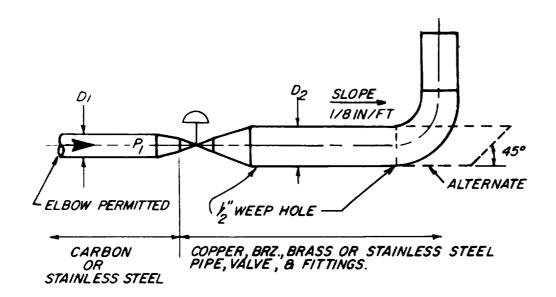
- 2. Silencers, if used, may be located at any point after 10 $\rm D_2$ straight run. Vent hood shall not be used on silencer as it increases noise level.
- 3. Valve shall be globe type.
- 4. Carbon or s.s. if $V \le 200$ ft/sec at small dia. Otherwise use Monel.

Figure 1. Pressure Control Vent Systems: $P_1 > 15$ PSIC

OXYGEN PIPING

D_i - SIZE AT V \subseteq 200 FPS
D - ONE FULL LINE SIZE
2 GREATER THAN D_i





NOTE: 1. See standard 570.8 for design criteria for exclusion of rain or snow. A plastic cap may be utilized at end of vent pipe for compressor dump systems.

2. Valve shall be globe type for pressure control and ball type for dump. See std. 570.7 for valve dump rate.

3. Silencer, when used, may be located at any point in D2 piping.

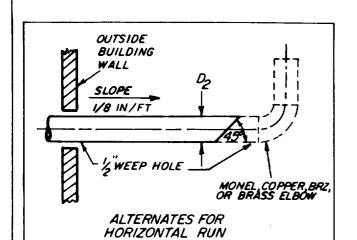
Figure 2. Pressure Control Vent & Compressor Dump Systems; $P_1 \le 15$ PSIG

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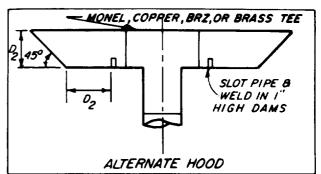
Date 4/24/72

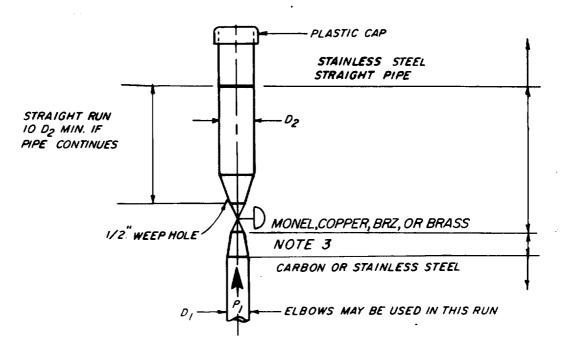
OXYGEN PIPING



D;- SIZE AT V \$\frac{1}{2}\circ OFPS\$

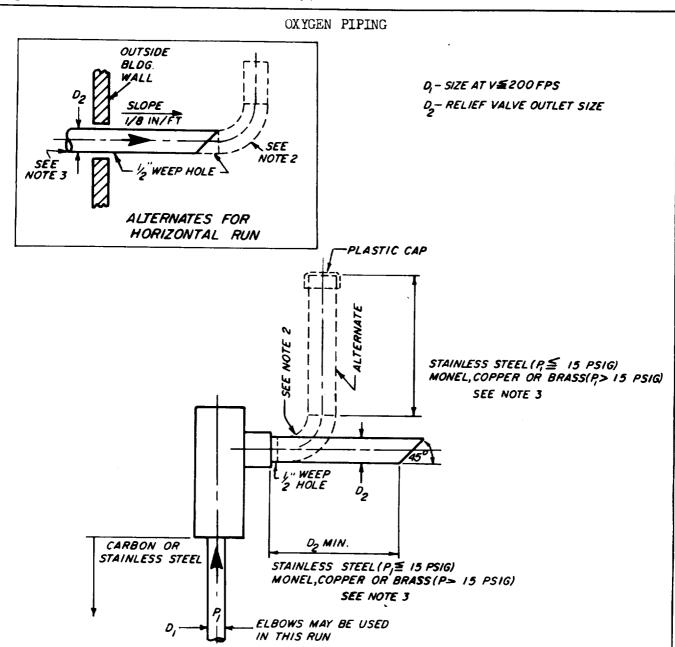
D2- ONE FULL LINE SIZE
GREATER THAN D;





- NOTE: 1. See standard 570.8 for design criteria for exclusion of rain or snow.
 - 2. Valve shall be ball type sized to vent pressure at rate required by standard 570.7
 - 3. Carbon or s.s. if $V \le 200$ ft/sec at small dia. Otherwise use Monel.

Figure 3. Compressor Dump Systems: $P_1 > 15$ PSIG



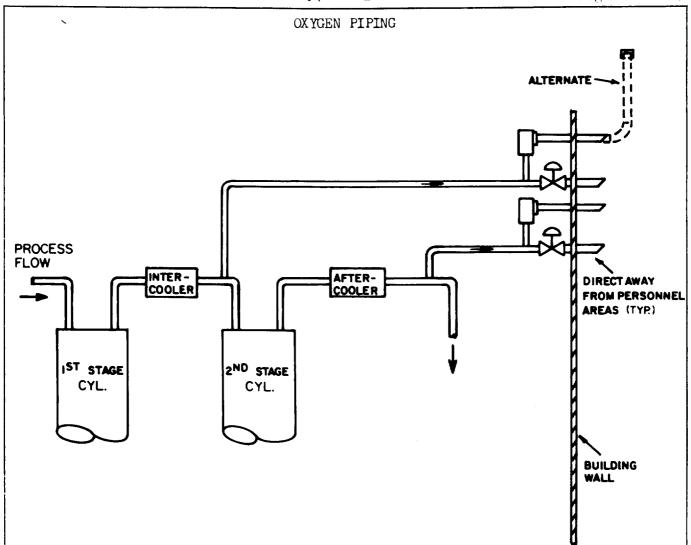
- NOTE: 1. See standard 570.8 for design criteria for exclusion of rain or snow.
 - 2. If elbow is required on outlet side of valve, it shall be of copper, Monel or brass, except stainless steel may be used when $P_1 \le 15$ psig.
 - 3. For $P_1 > 15$ PSIG: Straight outlet piping of stainless steel may be used after a straight length equal to 10 D₂ of copper, Monel or brass.
 - 4. Relief valve shall be bronze or stainless steel. Contained soft seats of Kel F or Teflon may be used.

Figure 4. Relief Valves, All Pressures

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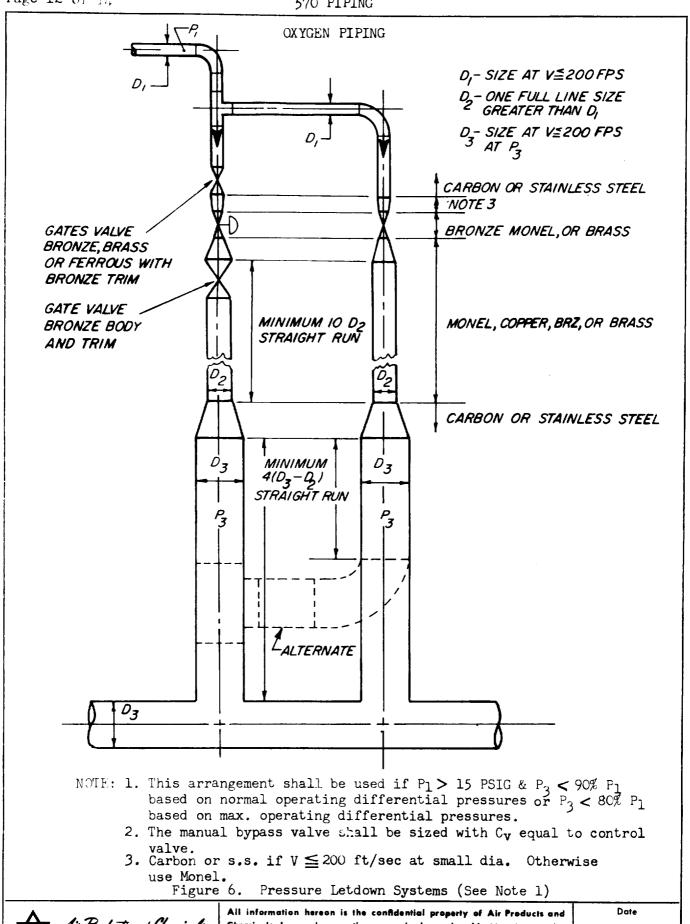
Date 4/24/72

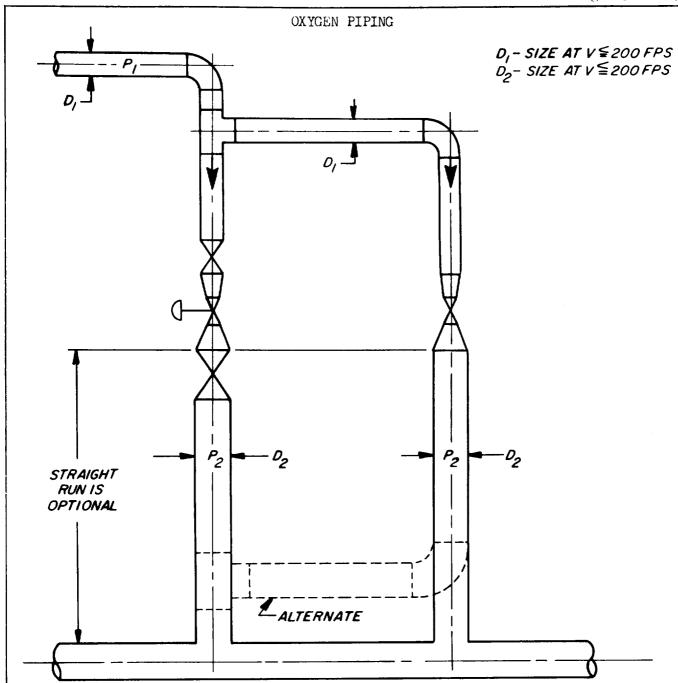


- NOTE: 1. Dump valves may be located immediately inside building wall and vented externally. Piping to valves shall be carbon or stainless steel and shall be sized for velocity below 200 ft/sec at maximum flow through valve and for a pressure drop below 1.0% of design operating pressure for applicable stage at maximum compressor flow conditions.
 - 2. Relief valves may be located immediately inside building wall and vented externally. Inlet to valve may tee off upstream of dump valves. If dump valves are not required for a particular stage, such as compressor suction, individual piping will be required to the relief valves. Allowable pressure drop in this piping shall be less than 1.0% of design operating pressure of applicable stage considering maximum compressor flow.
 - 3. A small platform and ladder shall be provided for maintenance of elevated valves as well as for replacement of plastic caps, if utilized.

Figure 5. Typical Indoor Vent Arrangement







All Piping: Carbon or stainless steel, copper, or brass All Valves: Ferrous metal with bronze trim, bronze or brass

NOTE:

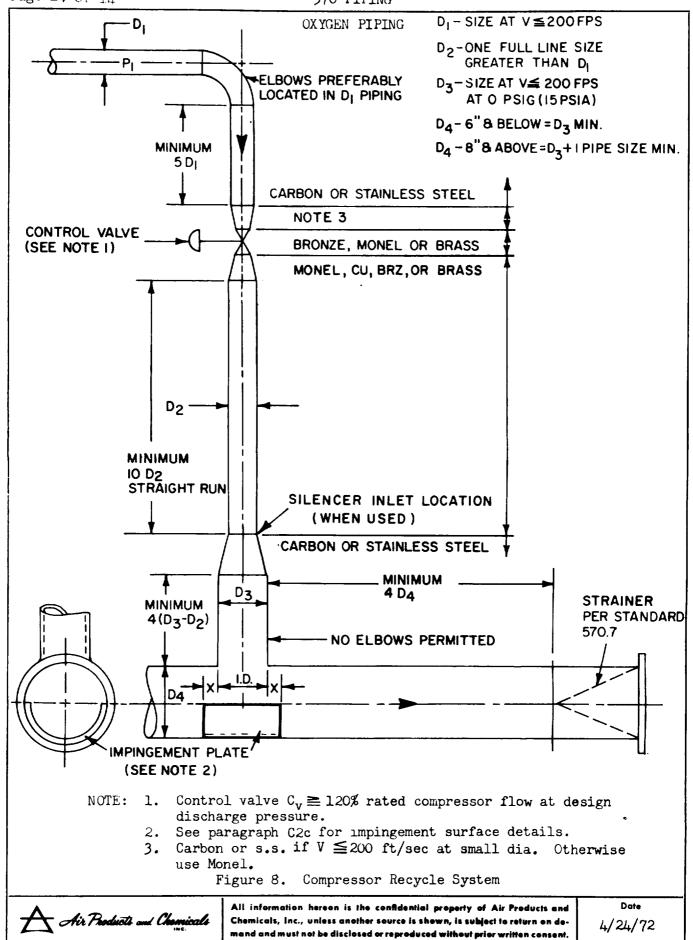
- 1. This arrangement shall be used if $P_1 \le 15$ PSIG and/or downstream pressure $P_2 > 90\%$ P_1 , based on normal operating differential pressures, or $P_2 > 80\%$ P_1 based on max. operating differential pressures.
- 2. The manual bypass valve shall be sized with $\mathbf{C}_{\mathbf{v}}$ equal to control valve.

Figure 7. Pressure Letdown Systems (See Note 1)

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Date 4/24/72



OXYGEN COMPRESSOR LOCATION

I. Purpose

This standard defines rules to be followed in locating an oxygen compressor system in a plant layout to achieve an economical and safe arrangement.

II. Scope

This standard applies to all oxygen compressing systems designed, installed or operated by APCI and is based on the use of personnel protective shields as required by Design Engineering Standard 546.1.

III. Responsibility

The oxygen compressor arrangement shall be reviewed by APCI Safety, Engineering and Operations Departments during the first equipment arrangement review meeting and shall be approved by these Departments prior to finalizing the layout.

IV. Introduction

From a process and first cost standpoint, the ideal location of an oxygen compressor system is in the vicinity of the cold box and close to electrical and cooling water supply; thus placing it amongst many pieces of major equipment and in natural access routes to this equipment. A truly economical and safe arrangement requires modification of this layout. Minimum distances must be maintained between plant equipment and the oxygen compressor dependent on the equipment's capability to withstand effects of an oxygen fire. More importantly, plant personnel and public safety must be maintained by the overall layout.

V. Equipment Location

The following minimum distances are intended to prevent crippling damage to surrounding equipment and minimize personnel exposure in case of an oxygen fire within the personnel protective shield. Increased distances may be required to minimize height of personnel shields as balanced against higher cost of longer pipe runs, etc.

Distance from Oxygen Compressor (min.)

A. Major Equipment (cold boxes, air compressors, etc.)

20 ft.

NOTE: Oil console for any other compressor shall be positioned so its compressor lies between the console and the oxygen compressor.

B. Back-up Equipment (storage tanks, pumps, vaporizers, electrical gear, etc.)

50 ft.

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Date

1/15/71

DESIGN ENGINEERING STANDARDS

570 PIPING

OXYGEN COMPRESSOR LOCATION Distance from Oxygen Compressor (min.) C. Flammable Equipment (cooling towers, etc.) 50 ft. D. Buildings (office, maintenance, etc., where people congregate) 50 ft. E. Natural Passage Ways (for normal plant operation) 10 ft. NOTE: 1. Except when intentionally going to oxygen compressor. 2. Where necessary, chain fences and signs shall be utilized to reroute personnel.

F. Public Thoroughfares or Buildings

50 ft.

CSO 1.5

DRY OXYGEN SERVICE	-20°F to +100°F 150 PSIG MAX	CARBON STEEL
: ITEM	<u>DESCRIPTION</u>	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH Seamless, Threaded Ends	ASTM A53 Gr B
1/2" thru 2"	Std. Seamless, Threaded Ends	ASTM A53 Gr B
4" and smaller	Std. Buttweld, Plain Ends	ASTM A53
6"	Std. Seamless, Plain Ends	ASTM A53 Gr B
8" thru 12"	Sch. 20, Seamless, Plain Ends	ASTM A53 Gr B
14" thru 24"	Sch. 10, Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS (For Tees, S	ee Note 3)	
2" and smaller	2000# Forged Steel, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 USAS B16.11
2 1/2" thru 6"	Sch. 40 Wrought Steel, Buttweld Ends	ASTM A234 WPB USAS B16.9
8" thru 12"	Sch. 20 Wrought Steel, Buttweld Ends (See Note 6)	ASTM A234 WPB USAS B16.9
14" thru 24"	Sch. 10, Wrought Steel, Buttweld Ends (See Note 6)	ASTM A234 WPB USAS B16.9
UNIONS		
2" and smaller	2000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Socket Weld Ends	ASTM AlO5 Gr 2 USAS Bl6.11
FLANGES		
2 1/2" thru 24"	150# Forged Steel, Flat Face, Slip-on	ASTM A181 Gr 1 USAS B1 ϵ .5
2 1/2" thru 24"	150# Forged Steel, Flat Face, Weld Neck, Bore for Sch. of Pipe	ASTM A181 Gr 1 USAS B16.5

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Date Sept.,1969

	570 PIPING	CSO 1.5 Page 2
DRY OXYGEN SERVICE	-20°F to +100°F 150 PSIG	MAX CARBON STEEL
ITEM	DESCRIPTION	SPECIFICATION
BOLTING		
All sizes	Studs, Carbon Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A307 Gr B ASTM A194 Gr 2H APCI 579.2.2
GASKETS		
All sizes	Full Face, Compressed Asbestos, Garlock 900, 1/16" thick	USAS B16.21 APCI 579.2.3
STRAINERS (See Note 8)	
All sizes	150# Conical Strainer, 100 Mesh Bronze or Monel screening in accordance with APCI Dwg. 92898	•
VALVES		
GATE		
2" and smaller	125# Bronze, Screwed Ends	V-12A
2 1/2" thru 24"	125# IBBM, Flat Face Flanged Ends	V-45F
GLOBE		
2" and smaller	150# Bronze, Screwed Ends	V-511A
2 1/2" thru 6"	150# Bronze, Flat Face Flanged Ends	V-513F
8" thru 12"	150# Cast STSTL, Type 304 or 316 with Bronze Disc, Disc Lock Nut, and Renewable Bronze Seat, Buttweld Ends	•
CHECK (See Note 7)		
2" and smaller	200# Bronze, Swing, Screwed Ends	s V-1511A
2 1/2" thru 12"	150# Aluminum-Bronze, Wafer-type Daniel "Chexter" 1601-E with Teflon Seal and Monel Pin.	;
GLOBE (FOR PRESSURE	GAUGE AND INSTRUMENT SHUT-OFF)	
1/4" and 1/2"	400# OWG Bronze, Needle Type Screwed Ends	V-2011A
Air Products and Chemicals	All information hereon is the confidential property of Chemicals, Inc., unless another source is shown, is subj mand and must not be disclosed or reproduced without pr	ect to return on de- Sept., 1969

578.60.3 Page 3

570 PIPING

DRY OXYGEN SERVICE

-20°F to +100°F

150 PSIG MAX

CARBON STEEL

ITEM

DESCRIPTION

SPECIFICATION

1. For oxygen piping concept, see Design Engineering Standard 578.60.1.

- 2. Bends may be used to replace ells where space permits. The bend radius shall in no case be less than 5 diameters based on the internal diameter of the pipe.
- 3. Tees shall be carbon steel, except under pressure let-down conditions.

When flow is into the side port, a Monel tee, ASTM B164, shall be used in sizes thru 6". In sizes 8" and larger, a brass impingement plate shall be installed in the straight run. Impingement plate shall be 1/8" thick half-hard rolled brass sheet, ASTM B36. Plate shall exceed branch diameter by 3" on each side, or for a total length of the branch diameter plus 6". Plate shall cover one-half the pipe circumference opposite of the main run, and tack-brazed in place.

- "Dry Oxygen Service" is gaseous oxygen service with a dew point of 4. -40°F.
- Socket weld fittings shall be used wherever possible. screwed end fittings and unions shall be kept to a minimum.
- 6. Ends to be bored to 0.250" wall, and bored back to a depth of 1/2" for use with weldings rings. Welding rings shall not be used in high velocity and pressure let-down conditions. Designer shall note on drawings where welding rings shall not be used.
- 7. Check valves listed herein are for use with centrifugal compressor systems only. For reciprocating compressor check valves, consult the Chief Design Engineer.
- Strainers shall be used only at the first stage suction connection of oxygen compressors, immediately adjacent to the inlet.

Air Products and Chemicals

Sept., 1969

CSO 2.7

DRY OXYGEN SERVICE	-20°F to +100°F 275 PSIG MAX	CARBON STEEL
ITEM	<u>DESCRIPTION</u>	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH Seamless, Threaded Ends	ASTM A53 Gr B
1/2" thru 2"	Std. Seamless, Threaded Ends	ASTM A53 Gr B
4" and smaller	Std. Buttweld, Plain Ends	ASTM A53
6"	Std. Seamless, Plain Ends	ASTM A53 Gr B
8" thru 12"	Sch. 20, Seamless, Plain Ends	ASTM A53 Gr B
14" thru 24"	Sch. 10, Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS (For Tees, See	e Note 3)	
2" and smaller	2000# Forged Steel, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Steel Socket Weld Ends	ASTM A105 Gr 2 USAS B16.11
2 1/2" thru 6"	Sch. 40 Wrought Steel, Buttweld Ends	ASTM A234 WPB USAS B16.9
8" thru 12"	Sch. 20 Wrought Steel, Buttweld Ends (See Note 6)	ASTM A234 WPB USAS B16.9
14" thru 24"	Sch. 10 Wrought Steel, Buttweld Ends (See Note 6)	ASTM A234 WPB USAS B16.9
UNIONS		
2" and smaller	2000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Socket Weld Ends	ASTM A105 Gr 2 USAS B16.11
FLANGES (See Note 7)		
2 1/2" thru 24"	150# Forged Steel, Raised Face, Slip-On	ASTM A181 Gr 1 USAS B16.5
2 1/2" thru 24"	150# Forged Steel, Raised Face, Weld Neck, Bore for Sch. of Pipe	ASTM A181 Gr 1 USAS B16.5
		

Date

Sept., 1969

CSO 2.7

DRY OXYGEN SERVICE	-20°F to +100°F 275 PSIC	G MAX CARBON STEEL
<u>EM</u>	DESCRIPTION	<u>SPECIFICATION</u>
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Studs, Carbon Steel, Full Thd (To be used only with C.I. & Bronze valves and equipment)	
CACHETTE (Can Note 7)	Nuts, Carbon Steel, Hex	ASTM A194 Gr 2H APCI 579.2.2
GASKETS (See Note 7)		
All sizes	Ring, Compressed Asbestos, Garlock 900, 1/16" thick	USAS B16.21 APCI 579.2.3
STRAINERS (See Note	9)	
All sizes	150# Conical Strainer, 100 Me Bronze or Monel screening in accordance with APCI Dwg. 928	
VALVES		
<u>GATE</u>		
2" and smaller	200# Bronze, Screwed Ends	V-11A
2 1/2" thru 16"	250# IBBM, Raised Face Flanged Ends	V-51G
CLOBE		
2" and smaller	150# Bronze, Screwed Ends	V-511A
2 1/2" thru 4"	300# Bronze, Flat Face Flanged Ends	V-523F
6" thru 12"	150# Cast STSTL, Type 304 or 316, with Bronze Disc, Disc Lock Nut, and Renewable Bronz Seat, Buttweld Ends	V-743C (Modific
CHECK (See Note 8)		
2" and smaller	200# Bronze, Swing, Screwed E	Ends V-1511A
2 1/2" thru 12"	300# Aluminum-Bronze, Wafer-t Daniel "Chexter" 1603-E with Seal and Monel Pin, (See Note	Teflon

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CSO 2.7

DRY OXYGEN SERVICE

-20°F to + 100°F 275 PSIG MAX

CARBON STEEL

ITEM

DESCRIPTION

SPECIFICATION

VALVES (Cont'd.)

GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)

1/4" and 1/2"

400# OWG Bronze, Needle Type

V-2011A

Screwed Ends

- NOTE: 1. For oxygen piping concept, see Design Engineering Standard 578.60.1.
 - 2. Bends may be used to replace ells where space permits. The bend radius shall in no case be less than 5 diameters based on the internal diameter of the pipe.
 - 3. Tees shall be carbon steel, except under pressure let-down conditions.
 - During let-down, when flow is into the side port, a Monel tee ASTM B164, shall be used in sizes thru 6". In sizes 8" and larger, a brass impingement plate shall be installed in the straight run. Impingement plate shall be 1/8" thick half-hard rolled brass sheet, ASTM B36. Plate shall exceed branch diameter by 3" on each side, or for a total length of the branch diameter plus 6". Plate shall cover one-half the pipe circumference of the main run, and tack-brazed in place.
 - 4. "Dry Oxygen Service" is gaseous oxygen service with a dew point of -40°F.
 - 5. Socket weld fittings shall be used wherever possible. The use of screwed end fittings and unions shall be kept to a minimum.
 - 6. Ends to be bored to 0.250" wall, and bored back to a depth of 1/2" for use with welding rings. Welding rings shall not be used in high velocity and pressure let-down conditions. Designer shall note on Drawings where welding rings shall not be used.
 - 7. 300# USAS raised face flanges shall be used with Daniel "Chexter" check valves and V-51G gate valves. 300# USAS flat face flanges shall be used with V-523F globe valves, and with a full face gasket.
 - 8. Check valves listed herein are for use with centrifugal compressor systems only. For reciprocating compressor check valves, please consult the Chief Design Engineer.
 - 9. Strainers shall be used only at the first stage suction connection of oxygen compressors, immediately adjacent to the inlet.

CSO 5



CSO 5

1age 2) (O 11.1NG 000	<u> </u>
DRY OXYGEN SERVICE	-20°F to +100°F 500 PSIG MAX OWG	CARBON STEEL
<u>ITEM</u>	<u>DESCRIPTION</u>	SEPCIFICATION
GASKETS (See Note 8)		
All Sizes	Ring, Compressed Asbestos, Garlock 900, 1/16" thick	USAS B16.21 APCI 579.2.3
STRAINERS (See Note 7)		
All sizes	300# Conical Strainer, 100 Mesh Bronze or Monel screening in accordance with APCI Dwg. 92898D. (Before specifying Design Piping Manager must be consulted.)	APCI Dwg. 92898D
VALVES		
GATE		
2" and smaller	350# Bronze, Screwed Ends	V-21A
2 1/2" thru 12"	250# IBBM, Raised Face Flanged Ends	V-51G
GLOBE		
2" and smaller	350# Bronze, Screwed Ends	V-521A
2 1/2" thru 4"	300# Bronze, Flat Face Flanged Ends	V-523F
6" and 8"	300# Cast STSTL, Type 304 or 316, with Bronze Disc. Disc Lock Nut, and Renewable Bronze Seat, Buttweld Ends	V756C (Modified)
CHECK (See Note 6)		
2" and smaller	350# Bronze, Swing, Screwed Ends	V-1521A
2 1/2" thru 12"	300# Aluminum Bronze, Wafer-Type, Daniel "Chexter" 1603-E with Teflon Seal and Monel Pin.	
GLOBE (FOR PRESSURE G.	AUGE AND INSTRUMENT SHUT-OFF)	
1/4" and 1/2"	3000# OWG Bronze, Screwed Ends, Hoke 2152F4B (1/4") and 2152F8B (1/2")	

CSO 5

DRY OXYGEN SERVICE

-20°F to +100°F

500 PSIG MAX OWG

CARBON STEEL

ITEM

DESCRIPTION

SPECIFICATION

NOTE:

- 1. For oxygen piping concept, see Design Engineering Standard 578.60.1.
- 2. Bends may be used to replace ells where space permits. The bend radius shall in no case be less than 5 diameters based on the internal diameter of the pipe.
- 3. Tees shall be carbon steel, except under pressure let-down conditions.

When flow is into the side port, a Monel tee ASTM B164, shall be used in sizes thru 6". In sizes 8" and larger, a brass impingement plate shall be installed in the straight run. Impingement plate shall be 1/8" thick half-hard rolled brass sheet, ASTM B36. Plate shall exceed branch diameter by 3" on each side, or for a total length of the branch diameter plus 6". Plate shall cover one-half the pipe circumference of the main run, and tack-brazed in place.

- 4. "Dry Oxygen Service" is gaseous oxygen service with a dew point of -40°F.
- 5. Socket weld fittings shall be used wherever possible. The use of screwed end fittings and unions shall be kept to a minimum.
- 6. Check valves listed herein are for use with centrifugal compressor systems only. For reciprocating compressor check valves, please consult the Chief Design Engineer.
- 7. Strainers shall be used only at the first stage suction connection of oxygen compressors, immediately adjacent to the inlet.
- 8. 300# USAS flat face flanges shall be used with V-523F globe valve, and with a full face gasket.
- 9. Welding rings shall not be used in high velocity and pressure letdown conditions. Designer shall note on drawings where welding rings shall not be used.

	570 PIPING	578.60.6
DRY OXYGEN SERVICE	-20°F to +100°F 720 PSIG MAX	CSO 7.2 Page 1 CARBON STEEL
ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH Seamless, Threaded Ends	ASTM A53 Gr B
1/2" thru 2"	Std. Seamless, Threaded Ends	ASTM A53 Gr B
12" and smaller	Std. Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS (For Tees,	See Note 3)	
2" and smaller	2000# Forged Steel, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Steel Socket Weld Ends	ASTM A105 Gr 2 USAS B16.11
2 1/2" thru 12"	Sch. 40 Wrought, Buttweld Ends	ASTM A234 WPB USAS B16.9
UNIONS		
2" and smaller	2000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Screwed Ends (See Note 5)	ASTM A105 Gr 2 USAS B16.11
2" and smaller	3000# Forged Carbon Steel, Ground Joint, Steel-to-Steel Seats, Socket Weld Ends	ASTM A105 Gr 2 USAS B16.11
FLANGES		
2 _. 1/2" thru 12"	300# Forged Steel, Raised Face, Slip-On	ASTM A181 Gr 1 USAS B16.5
2 1/2" thru 12"	300# Forged Steel, Raised Face, Weld Neck, Bore for Standard Weight Pipe	ASTM A181 Gr 1 USAS B16.5
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 B7 ASTM A194 Gr 2H APCI 579.2.2
GASKETS	• • • • • • • • • • • • • • • • • • •	

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All sizes

Ring, Compressed Asbestos, Garlock 900, 1/16" thick

USAS B14.21 APCI 579.2.3

050 7.2

Page 2

DRY OXYGEN SERVICE	-20°F to +100°F 720 PSIG MAX	CARBON STEEL
ITEM	DESCRIPTION	SPECIFICATION
VALVES		
GATE		
2" and smaller	350# Bronze, Screwed Ends	V-21A
2 1/2" thru 12"	300# Cast Steel with Bronze or Monel Wedge, Buttweld Ends	V-1310 (Modified)
GLOBE		,
2" and smaller	350# Bronze, Screwed Ends	V-521A
2 1/2" thru 8"	300# Cast STSTL, Type 316 with Bronze Disc, Disc Lock Nut, and Renewable Bronze Seat, Buttweld Ends	V-756C (Modified)
CHECK (See Note 7)	•	
2" and smaller	350# Bronze, Swing Screwed Ends	V-1521A
2 1/2" thru 12"	600# Aluminum-Bronze, Wafer-type, Daniel "Chexter" 1605-E with Teflon Seal and Monel Pin (See Note 6)	
GLOBE (FOR PRESSURE	GAUGE AND INSTRUMENT SHUT-OFF)	
1/4" and 1/2"	3000# CWG Bronze, Screwed Ends, Hoke 2152F4B (1/4") and 2152F8B (1/2")	

- NOTE: 1. For oxygen piping concept, see Design Engineering Standard 578.60.1.
 - Bends may be used to replace ells where space permits. The bend radius shall in no case be less than 5 diameters based on the internal diameter of the pipe.
 - 3. Tees shall be carbon steel, except under pressure let-down conditions.

When flow is into the side port, a Monel tee, ASTM B164, shall be used in sizes thru 6". In sizes 8" and larger, a brass impingement plate shall be installed in the straight run. Impingement plate shall be 1/8" thick half-hard rolled brass sheet, ASTM B36. Plate shall exceed branch diameter by 3" on each side, or for a total length of the branch diameter plus 6". Plate shall cover one-half the pipe circumference of the main run, and tack-brazed in place.

578.60.6 Page 3

CSO 7.2

DRY OXYGEN SERVICE

-20°F to +100°F

720 PSIG MAX

CARBON STEEL

ITEM

DESCRIPTION

SPECIFICATION

NOTES (Cont'd.)

- 4. "Dry Oxygen Service" is paseous oxygen service with a dew point of -40°F.
- 5. Socket weld fittings shall be used wherever possible. The use of screwed end fittings and unions shall be kept to a minimum.
- 6. 600# USAS flanges shall be used with Daniel "Chexter" check valves.
- 7. Check valves listed herein are for use with centrifugal compressor systems only. For reciprocating compressor check valves, please consult the Chief Design Engineer.
- 8. Strainers shall be used only at the first stage suction connection of oxygen compressors, immediately adjacent to the inlet.
- 9. Welding rings shall not be used in high velocity and pressure letdown conditions. Designer shall note on drawings where welding rings shall not be used.

STAINLESS STEEL VALVES

MATERIAL REQUIREMENTS

1. PURPOSE

The purpose of this standard is to establish a list of material requirements for stainless steel valves.

2. SCOPE

All valve vendors must comply with the following material requirements for stainless steel valves.

3. MATERIAL

- A. Stem 18-8 SS (Austenitic Stainless).
- B. Disc Lock Nut or Holder Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- C. Bonnet and Packing Gland Bolting 18-8 SS studs, bolts and nuts (Austenitic Stainless).
- D. Yoke 18-8 SS (Austenitic Stainless).
- E. Yoke Nut Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- F. Yoke Retaining Nut (when required) Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- G. Packing Gland Flanges 18-8 SS (Austenitic Stainless).
- H. Packing Gland Follower Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- I. Bonnet Backseat Bushing Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- J. Packing Washer Brz, Ni-Brz, Mn-Brz, Al-Si-Brz (Ampco Metal) or Naval Brass.
- * K. Bonnet Gasket Suitable for temperature range from +400°F to -400°F.
 One extra gasket to be supplied with each valve.
 - L. Seats Integral or renewable (stellited when specified).
 - M. Disc Inserts (when specified) Kel-F 81 or 25% glass filled Teflon. (Vendor must be in full compliance with 579.3.2).
- All bonnet gaskets shall be hydrocarbon decontaminated,

Air Products and Chamicals

STAINLESS STEEL VALVES

3. MATERIAL (Cont'd)

- N. Disc (Gate Valve)
 - a. 2" and inder (1440# OWG rating or less) Solid or split wedge-Brz, Ni-Brz, Al-Si-Brz (Ampco Metal), Mn-Brz or Naval Brass.
 - b. 2" and under (above 1440# OWG rating) Solid wedge 18-8 SS.
 - c. 2 1/2" and larger Double disc (split wedge or ball and socket type) Brz, Ni-Brz, Al-Si-Brz (Ampco Metal), Mn-Brz or Naval Brass.
- O. Disc (Globe Valve) Brz, Ni-Brz, Al-Si-Brz (Ampco Metal), Mn-Brz or Naval Brass.
- P. Extension Tube (when required) 18-8 SS pipe or tube with wall as thin as possible to minimize heat leak but compatible with pressure and torque requirements.
- Q. Vendors are requested to have no situations where a moving part of 18-8 SS is in contact with another part of 18-8 SS. Bronze material against 18-8 SS provides a satisfactory non-galling condition.
- R. Vendor shall pack valves with square, braided 100% pure white asbestos yarn, free from all lubrication and graphite Garlock 5705 or equal.
- S. Vendor shall supply one additional set of hydrocarbon decontaminated packing, sealed in a plastic bag, wired to the yoke or bonnet. This packing shall be square, braided 100% pure asbestos Teflon coated yarn, free from all lubrication and graphite level of hydrocarbon contamination of this packing shall not exceed a value of 0.2% by weight-Garlock 5818 or equal.

MATERIAL REQUIREMENTS

1.TRODUCTION

EXTENDED BONNET VALVE CODE

1. PURPOSE

Standard 579.4 provides for the specification of extended bonnet valves and is issued to facilitate the preparation of Bills of Material, Requisitions, Purchase Orders, and inventory records.

2. SCOPE

Standard 579.4 specifies extended bonnet valves, in all styles and materials suitable for low temperature service, used by Air Products and Chemicals, Inc. for process piping within cold zone areas. This Introduction includes:

- A. The method of designation
- B. The uses of designators
- C. Purchase Requisitions
- D. Table of valve styles and materials
- E. Table of valve end designations
- F. Extended bonnet valve dimension sheet
- G. Special design requirements for APCI Extended Bonnet Valves

3. METHOD OF DESIGNATION

The method of designation shall be similar to that described in Paragraph 3 of 579.3 Introduction, except for the following:

A. The prefix to the valve number shall become "EBV" for Extended Bonnet Valves instead of the "V" for hand valves.

The basic valve design represented by the number following the prefix "EBV" in Section 579.4 is similar to that of the corresponding number following the prefix "V" in Section 579.3.

B. An additional numerical suffix shall be added after the letter indicating the type of end connection. This suffix shall indicate the bonnet extension (dimension "E" on the extended bonnet valve dimension sheet) and should be inserted in place of the "XX" on the valve Tag No.

For Example: A 3" EBV-11D with and "E" dimension equal to 26" shall be designated as 3" EBV-11D-26.

4. USES OF DESIGNATIONS

See Paragraph 4 of 579.3 Introduction.

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Air Products and Chronicals

570 PIPING

INTRODUCTION

EXTENDED BONNET VALVE CODE

5. PURCHASE REQUISITIONS

Purchase requisitions shall carry the valve designator (or valve tag no.) and shall specify special trim, bore for proper pipe schedule (buttweld valves) and any deviations from valve standards.

Special valves shall be specified completely on the purchase requisition.

6. VALVE STYLES AND MATERIALS

See Paragraph 6, Table I, of 579.3 Introduction.

7. VALVE END DESIGNATIONS

See Paragraph 7, Table II, of 579.3 Introduction.

8. EXTENDED BONNET VALVE DIMENSION SHEET

The extended bonnet valve dimension sheet provides the necessary roughing in dimensions for piping design studies. Dimensions given are maximum unless noted otherwise.

The "E" dimension shown is the minimum allowable length. This length may be increased by 3 inch increments only to the desired bonnet extension length and inserted in place of the "XX" on the valve tag no.

Valve mounting plates shall conform to the dimensions shown.

9. SPECIAL DESIGN REQUIREMENTS

- A. Stem shall be loose with free running threads when unpacked.
- B. Bonnet extension tube and mounting plate shall be stainless steel type 304.
- C. Bonnet bolting (where applicable) shall be austenitic stainless steel (18-8) or silicon copper.
- D. Stem shall be solid single piece construction of austenitic stainless steel.
- E. Packing gland shall be concentric and parallel to centerline of stem.
- F. Normal operating temperature plus 100°F to minus 325°F.

INTRODUCTION

EXTENDED BONNET VALVE CODE

9. SPECIAL DESIGN REQUIREMENTS (Cont'd)

- G. Mounting plates shall be provided by vendor on all extended bonnet valves up to and including 1 inch in size unless noted otherwise on the purchase order.
- H. Vendor shall pack valves with square, braided 100% pure white asbestos yarn, free from all lubrication and graphite Garlock 5705 or equal.
- J. Vendor shall supply one additional set of hydrocarbon decontaminated packing, sealed, in a plastic bag, wired to the yoke or bonnet. This packing shall be square, braided 100% pure asbestos Teflon coated yarn, free from all lubrication and graphite level of hydrocarbon decontamination of this packing shall not exceed a value of 0.2% by weight-Garlock 5818 or equal.
- K. Vendors shall supply one (1) spare bonnet gasket where applicable.
- L. The decontamination operation on all extended bonnet valves shall be performed in accordance with the applicable quality control procedure by or under the supervision of Air Products and Chemicals, Inc. The pure white asbestos stem packing should remain in the valve until this operation has been completed.
- M. Extended bonnet valves procured for field erection shall be decontaminated on location and outfitted with new stem packing and bonnet gasket (where applicable) after plant has completed its dry run.
- N. Additional requirements for stainless steel valves are specified in Design Engineering Standard 579.3.1.
- Q. For all valves 1" and under which require mounting plates, the vendor is to furnish the necessary quantity of Ohio Weld Nuts (Type ND 3/8" 16 NC) inserted in the holes in the mounting plate and tack welded to the back (valve body side) of the plate.

VALVE PROCUREMENT & CLEANING PROCEDURE

1. PURPOSE

This standard provides a policy for the procurement and processing of critical service valves requiring hydrocarbon decontamination.

2. SCOPE

This standard is intended to include the following critical service items:

- A. All extended bonnet valves, hand and diaphragm motor operated.
- B. All valves in a stream of 50% oxygen or over, called an "oxygen rich" stream.
- C. Defrost valves used in an "oxygen rich" stream.
- D. All valves in a high purity product stream requiring a minimum of contamination.
- E. All safety valves or devices used in an oxygen rich stream.

3. POLICY

Decontaminate all valves intended for critical service.

- A. Safety valves to be decontaminated by vendor in accordance with procedures approved by Air Products, Incorporated, Quality Control.
- B. Motor operated valves, extended bonnet and warm (non-extended) for use in or on shop fabricated or field erected boxes or equipment, shall be decontaminated by the vendor in accordance with procedures approved by Air Products, Incorporated, Quality Control.
- C. Hand operated valves, extended bonnet and warm (non-extended) for use in or on shop fabricated boxes or equipment shall be decontaminated by Air Products, Incorporated, Material Control Department, in accordance with procedures approved by Air Products, Incorporated Quality Control.
- D. All other valves, procured by Air Products, Incorporated or the Contractor for installation in or on field erected boxes or equipment requiring decontamination, shall be decontaminated by the Contractor in accordance with procedures approved by Air Products, Incorporated, Quality Control.

4. RESPONSIBILITY

A. It shall be the responsibility of the Design Engineering Section to clearly define by means of the Valve Summary, Consolidated Valve Bills of Material, Line Bills of Material, piping drawing, and Instrument Schedules those valves requiring decontamination.

Air Products and Chemicals

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Date

8-12-60

570 PIPING

VALVE PROCUREMENT & CLEANING PROCEDURE

4. RESPONSIBILITY (Cont'd)

- B. It shall be the responsibility of the Project Engineering Section to transmit to the Manufacturing Department through the means of the I.W.O. system all necessary and pertinent data* relative to the ordering and decontamination of valves.
 - * Pertinent data is defined as:
 - (1) The applicable, specific project sections and sub-sections.
 - (2) Specific decontamination requirements.
 - (3) Complete listing of those valves intended for assembly in shop fabricated boxes.
- C. It shall be the responsibility of the Project Engineering Section to process in their entirety all requisitions pertaining to hand valves intended for direct shipment to the field.
- D. It shall be the responsibility of the Project Engineering Section to submit to the Manufacturing Department, all requisitions for hand or motor operated valves within the category of, part field and part shop erected, for the purpose of recording data related to shipping dates, shipping instructions, decontamination instructions and manufacturing approval.
- E. It shall be the responsibility of the Purchasing Department to screen all requisitions for manufacturing approval where valves are directed to Air Products, Incorporated shops.

Requisitions not properly authenticated by the Manager of Production Planning or his assignee the Planning Supervisor shall be rejected by the Purchasing Department and returned for proper authorization.

5. VALVE REQUSITION DATA

A. The following data (in the order shown) shall be made a part of all valve requisitions except those issued by Project Engineering for direct shipment to the field.

Shipping Instructions: (to be used only where more than one item is ordered).

VALVE PROCUREMENT & CLEANING PROCEDURE

5.	VALVE	REQUISITION	DATA	(Cont'd)	١

Item No. Quantity

Date Required

Ship To

Decontamination Instructions: (applicable to all valve requisitions)

(are)
Valves (are not) to be decontaminated by vendor

Receiving Dept. Note:

6. GENERAL

- A. Valve packing and bonnet gasket data shall conform with requirements as indicated in applicable Design Engineering Standards.
- B. Decontaminated valves shall be supplied by the Material Control Department where specified on the Manufacturing Bills of Material.

TRANSITION JOINTS

ALUMINUM TO STAINLESS STEEL

PURPOSE

This standard provides the approved data relative to effecting a permanent metal to metal joint between the dissimiliar metals, aluminum and stainless steel with the option of boring the stainless steel end to receive 0.D. copper tubing silver soldered in place.

2. SCOPE

The transition joints covered by this standard have been found suitable for use with gaseous and liquid oxygen or nitrogen and should not be used for a corrosive fluid.

Design pressures should not exceed 150 PSIG. Design temperatures are restricted to a maximum of plus 200°F and a minimum of minus 325°F.

3. CONSTRUCTION

Materials shall be aluminum 6061 ends beveled for standard weight pipe and stainless steel 304 or 316 ends beveled or bored as indicated in the following tables.

The overall lengths of the purchased joints shall be:

3/4" IPS through 5" IPS - Minimum 3", Maximum 6". (For joints with bored ends, length shall be 6").

6" IPS Minimum 3", Maximum 7 1/2"

NOTE: 1. Joints used internally on cold boxes should be restricted to 4" IPS maximum.

2. Approved sources:

- A. Tube Turns
- B. Bi-Braze Corporation
- C. Solar
- 3. APCI Dwg. 88200A will be superseded by this standard.

570 PIPING

TRANSITION JOINTS

ALUMINUM TO STAINLESS STEEL

ITEM NO.	NOMINAL PIPE SIZE	BEVEL SS END FOR SCH	MATERIAL CODE NUMBER
1	1" .	108	4-477-69-0085
2	1"	408	4-477-69-0086
3	1 1/2"	108	4-477-69-0087
4	1 1/2"	40S	4-477-69-0088
6	2"	108	4-477-69-0090
7	2"	40S	4-477-69-0091
8	2 1/2"	58	4-477-69-0092
9	2 1/2"	105	4-477-69-0093

ITEM NO.	NOMINAL PIPE SIZE	BEVEL SS END FOR SCH	MATERIAL CODE NUMBER
10	3"	5 S	4-477-69-0094
11	3"	105	4-477-69-0095
12	4"	5 S	4-477-69-0096
13	4"	10S	4-477-69-0097
14	6"	5 S	4-477-69-0098
15	6"	108	4-477-69-0099
16			
17			

ALUMINUM TO STAINLESS STEEL (FOR COPPER TUBE TRANSITION)

ITEM NO.	NOMINAL PIPE SIZE (AL END)	NOMINAL TUBE SIZE (SS END)	MATERIAL FOR SS END	DIAMETER OF BORE (SS END)	DEPTH OF SOCKET (SS END)	MATERIAL CODE NUMBER
30	1"	1 1/8"OD	1" SCH 40S	1.128 1.131	7/8"	4-477-69-0109
31	1 1/2"	1 5/ 8"OD	1 1/2" SCH 80S	1.628 1.631	1"	4-477-69-0110
32	2"	2 1/8"OD	2" SCH 40S	2.128 2.131	1"	4-477-69-0111
33	2 1/2"	2 5/8"OD	2 1/2" SCH 40S	2.628 2.631	1"	4-477-69-0112
34	3"	3 1/8"OD	3" SCH 40S	<u>3.128</u> 3.131	1"	4-477-69-0113
35	4"	4 1/8"OD	4" SCH 40S	<u>4.128</u> 4.131	1 1/8"	4-477-69-0114

Air Products and

Chemicals, Inc.

TECHNICAL BULLETIN

Bulletin No. 39

Applicable to: Standard 581.1

SUBJECT: Use of Perlite in Air Separation Cold Boxes

Due to mechanical and safety problems associated with the use of perlite in air separation plant cold boxes, this material is prohibited in those units currently under construction or in future designs.

An exception to this rule may apply to very small plants, such as USAF TAC units, having physical dimensions prohibiting the use of other insulation materials. The use of perlite for these special cases shall be specifically approved by the Director of Engineering Design Policy.

ORIGINAL SIGNED BY

R. W. Campbell 6/14/71

B. W. Taylor 6/14/71 June 14, 1971

DATE:

580 INSULATION & PAINTING

COLD ZONE

INSULATION

Cold Boxes
Thermal Tanks

PERLITE

1. PURPOSE

This standard provides the necessary information required to evaluate the use of Perlite as a cold zone insulation and provides reference to purchase specification for them.

2. SCOPE

The following grades outlined herein have been established by this standard as meeting all the requirements of the present applications.

3. GRADE "A"

A. Chemical Composition

It shall contain approximately 76% silica, 14% alumina and lesser amounts of trivalent oxides. Other characteristics are:

- (1) Inert (substantially free of other inorganic material)
- (2) Insoluble in water and most acids
- (3) Non-combustible (has fusion point of 2200°F)
- (4) Essentially neutral
- (5) Non-conductive
- (6) Resilient

B. Sieve Analysis

The sieve analysis shall be as follows:

U.S. SIEVE NO.	PERCENTAGE WEIGHT RETAINED
16	5-10
30	25-3 5
50 100	50-60
100	80-90
200	90-100

C. Density

This grade shall have a compacted density of 7 to 10 pounds per cubic foot.

Method of determining compact density - Use a smooth wall drum of approximately 50 gallon capacity. Fill it approximately 3/4 full with Perlite Grade A, calculate its density. Then vibrate drum by tapping with 1# rubber mallet for 100 blows around lower perifery of drum. Leave drum set for one week, then vibrate drum again with 100 blows of the mallet. Calculate compact density.

Page 2

580 INSULATION & PAINTING

COLD ZONE

INSULATION

Cold Boxes
Thermal Tanks

PERLITE

3. GRADE "A" (Contd)

D. Thermal Conductivity

If available the "K" factor for the temperature range of - 320°F to 70°F at atmospheric pressure and vacuum shall be reported.

- E. Shipping
 - (1) Package 4 Cu. Ft.

The grade "A" Perlite shall be shipped in multiwall paper bags containing 4 (four) cubic feet of material and the as shipped moisture content is less than 0.5% and the material will not pick up any appreciable amount of moisture unless the bag becomes damp.

(2) Bulk

The grade "A" Perlite shall be shipped clean, free from foreign contaminations, protected from the elements and with a moisture content of less than 0.5%.

4. GRADE "B"

A. Chemical Composition

It shall contain approximately 76% silica, 14% alumina and lesser amounts of trivalent oxides. Other characteristics are:

- (1) Inert (substantially free of other inorganic material)
- (2) Insoluble in water and most acids
- (3) Non-combustible (has fusion point of 2200°F)
- (4) Essentially neutral
- (5) Non-conductive
- (6) Resilient
- B. Sieve Analysis

The sieve analysis shall be as follows:

U.S. SIEVE NO.		PERCENTAGE	WEIGHT	RETAINED
16		Max	10	
30		30 -	40	
50		60 -	80	
100		80 -	95	
200	\	95 -	100	

580 INSULATION & PAINTING

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INSULATION

Cold Boxes
Thermal Tanks

COLD ZONE

PERLITE

4. GRADE "B" (Contd)

C. Density

This grade shall have a compacted density of 4 to 6 pounds per cubic foot.

Method of determining compact density - Use a smooth wall drum of approximately 50 gallon capacity. Fill it approximately 3/4 full with Perlite Grade B, calculate its density. Then vibrate drum by tapping with 1# rubber mallet for 100 blows around lower perifery of drum. Leave drum set for one week, then vibrate drum again with 100 blows of the mallet. Calculate compact density.

D. Thermal Conductivity

If available the "K" factor for the temperature range of - 320°F to 70°F at atmospheric pressure and vacuum shall be reported.

E. Shipping

(1) Package - 4 cu. ft.

The grade "B" Perlite shall be shipped in multiwall paper bags containing 4 (four) cubic feet of material and the as shipped moisture content is less than 0.5% and the material will not pick up any appreciable amount of moisture unless the bag becomes damp.

(2) Bulk

The grade "B" Perlite shall be shipped clean, free from foreign contaminations, protected from the elements and with a moisture content of less than 0.5%.

5. APPLICATION

Grade "A" is recommended for atmospheric service (cold box).

Grade "B" is recommended for general service, suitable for vacuum or make-up in atmospheric service.

Grade "B" is recommended for Air Products, Incorporated warehouse stock.

Any jobs requiring shop packing of perlite must use grade "B". Grade "A" is used only for field erected boxes.

DESIGN ENGINEERING STANDARDS

581.1 Page 4

580 INSULATION & PAINTING

COLD ZONE INSULATION

Cold Boxes Thermal Tanks PERLITE

6. REQUISITION

Requisitions should reflect unit quantities in bags suffixed by total quantities of cubic feet, based on loose density.

NOTE: In computing quantity required, use average compacted density.

7. PURCHASE SPECIFICATIONS

DESCRIPTION	PURCHASING SPECIFICATION
Insulation Perlite Grade "A"	580.10.1
Insulation Perlite Grade "B"	580.10.2



COLD INSULATION

MINERAL FIBER GRANULATED

1. PURPOSE

The purpose of this standard is to establish the criteria necessary for selecting granulated mineral fiber which will be suitable for insulating cryogenic and low-temperature piping and equipment in metal ducts and jackets (cold boxes).

2. SCOPE

This specification shall apply to granulated mineral fiber used between plus 600°F and minus 425°F in metal ducts and jackets (cold boxes).

3. DESCRIPTION AND SPECIFICATIONS

A. Chemical Characteristics

(1) The chemical composition of the mineral wool shall be within the following ranges:

CHEMICAL	AVERAGE	PERCENTAGE
	Min.	Max.
Silica (Si O ₂) Alumina (Al ₂ O ₃)	35.0	48.0 20.0
Iron Oxide (FeO) Calcium Oxide (CaO)		25.0 41.0
Magnesium Oxide (MgO)		15.0
Sulphur (S)		1.6

- (2) The moisture content as determined by loss in weight @ 225°F shall be 0.2% max.
- (3) The ignition loss as determined by weight loss @ 1000°F minus weight loss @ 225°F shall be 0.175% max. This is equivalent to adding no more than 3.5 pounds of oil per ton of fiber.
- (4) The mineral fiber shall be inert under conditions of moisture or heat so as not to cause or promote corrosion. It shall have a pH value of 6 to 7 when tested in accordance with procedures called out in Specification MIL-I-24244.

B. Physical Data

(1) Cleanliness

The mineral fiber shall be granulated, and well modulated. It shall not contain trim or waste from mineral wood boards, batts or other products and shall be free from foreign material and large, nonfibrous particles.

580 INSULATION AND PAINTING

COLD INSULATION

MINERAL FIBER GRANULATED

(2) Tunneling Characteristics

After the mineral fiber has been installed, it often becomes necessary to tunnel through it at various elevations. The fiber shall not collapse at the supplier's recommended installed density when the fiber is being tunneled.

(3) Shot Content

Shot content, consisting of pellets retained on a U.S. No. 50 or larger sieve (determined in accordance with Commercial Standard CS-131, Section IX) shall not exceed 10% by weight.

(4) Density

The vendor shall specify the density to which the mineral fiber must be packed in order that it shall withstand applied loads approximately that of a man stepping on it (400-600 lb./ft.²). It must be crush resistant and not crumble under these conditions. It is expected that this density may range from 12 to 17 pounds/cu. ft. in the packed condition.

(5) Thermal Conductivity

The thermal conductivity of the fiber shall not exceed 0.27 BTU/Hr.-Ft.² °F/in. (@ 32°F mean temperature and packed to the vendor's specified density) as determined using ASTM C-177 test procedures.

4. REQUISITION

Requisitions shall state <u>total</u> quantities required by pounds based on the vendor's recommended average packed density. It is expected that this packed density will vary from 12 to 17 pounds/cu. ft. The number of containers shall be based on the vendor's most economical container weight but shall also meet the requirements of paragraph 5.

5. PACKAGING

The mineral fiber shall be supplied in containers which are moisture resistant, puncture and tear resistant, and suitable for shipment by common carrier. The containers must be of a size and type which are readily handled in the field or shop.

6. SUPERSEDED

Design Standard 581.2, dated August 1966, is superseded by this standard.

580 INSULATION & PAINTING

COLD ZONE

INSULATION

Cold Boxes
Thermal Tanks

GLASS WOOL

1. PURPOSE

This standard provides the necessary specifications for requisitioning glass wool insulation for cold temperature service.

2. SCOPE

The temperature range for which this material is intended will be, plus 600°F to minus 400°F.

3. SPECIFICATIONS

Institution, Fiber Glass, Basic Fiber No. 28, Type E Glass, 25 lb. cartons. Maximum allowable hydrocarbon content shall be 0.175% by weight.

4. REQUISITION

Requisitions shall indicate the number of 25 lb. cartons based on a density of 6 lbs. per cubic foot of installed insulation.

NOTE: Compute quantities required on basis of 6 lbs. per cubic foot of space to be packed.

Owens - Corning Fiber Glass Division, Ashton, Rhode Island.

5. MATERIAL CODE NUMBER

1-521-27-0101 INSULATION GLASS FIBERGLASS #28 TYPE E 25# BOX 581.3

REFERENCE: API 43204A



APCI DOCUMENT

AIR SEPARATION

PURPOSE

This standard establishes the parameters by which a proposed site for an air separation plant should be analyzed.

2. SCOPE

This standard applies to all air separation plants.

INTRODUCTION 3.

In locating an air plant, we want to eliminate as far as possible persistent safety problems which can very easily be created when a plant is poorly located. The goal is a safe plant -- safe for personnel and free from operating interruptions due to accidents. The key to safety rests in careful consideration of environment and space. Based on these, we must answer:

- Is the site suitable at all?
- B. If so, must the cycle or plant layout be modified to overcome specific undesirable features?

4. ENVIRONMENTAL FACTORS

Among the environmental factors deserving attention are:

- A. Atmospheric contamination.
- B. Exposure to hazards from other units.
- C. Effects of the plant on surroundings.
- D. Terrain.
- E. Climate.
- F. Fire and police protection.
- Plant access and communications.

(1) Atmospheric Contamination

Since air from the atmosphere is the raw material for an oxygen plant, its purity is a most important environmental factor. Atmospheric contamination is not readily predictable, but by studying the properties of contaminants, their sources, and their distribution in the atmosphere, practical decisions can be made in determining the suitability of a location and the necessary adaptation required for a plant to fit a given location.

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605 PLANT SITE CRITERIA

AIR SEPARATION

4. ENVIRONMENTAL FACTORS (Contd)

a. Types

In selecting an air plant site, the contaminants of greatest concern are those which are combustible with oxygen and, more particularly, those which have certain physical properties similar to oxygen, thus enabling them to penetrate into oxygen-rich portions of the system. The low boiling hydrocarbons form the most critical group. These include methane, ethane, ethylene, acetylene, and to a lesser degree, C3 and C4 hydrocarbons. Ozone and oxides of nitrogen deserve some consideration, because experimentally it has been shown that they may contribute to reactions in liquid oxygen. However, their real significance is somewhat speculative because of the extremely low concentrations actually found in vulnerable parts of air separation equipment.

Aside from the cumbustible ones, we are concerned about compounds which may be corrosive to the metal surfaces of the plant, both internal and external. Particulate matter, the subject of many municipal air pollution control programs, is somewhat less critical among the siting criteria for an oxygen plant, but is related to the selection of air filters and to plant cleanliness.

b. Sources

Air pollution can come from a number of sources. Vents, stacks, flares, disposal areas, and process leaks are the more serious ones. Their presence must be viewed in the light of distance and possible corrective action. When the source is located across the fence in a neighboring plant, corrective action may be difficult. If the source is under the plant's control, corrective action becomes a matter of cost or planning. It is well worth remembering that a source of impurities may appear after the survey for the plant site is made. The possibility of a nearby vacant lot becoming a chemical plant must be kept in the back of one's mind, but more directly, when the oxygen plant is part of a larger complex, the plans for adjacent units within the fence must be analyzed. Knowledge of sources, present and future, should be collected and displayed on a chart of the proposed plant and its surroundings within 900 feet. The location of all stacks and flares and other possible contributors to air pollution should be marked, showing approximate elevations and the composition of effluent gases. Supplementing this sketch should be a chart showing any possible sources within a radius of about a mile (See Section 610.1.1 Check List Air Separation Plant Site).

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AIR SEPARATION

4. ENVIRONMENTAL FACTORS (Contd)

b. Sources (Contd)

Within the proposed plant area and very close to its surroundings, the possibility of process leaks warrants careful attention. It may be necessary to re-route process lines, for a major leak close to an air intake can be more critical than a general atmospheric condition which is continuously poor.

Contaminant levels at a source of pollution can vary considerably. Obviously, from a process leak, a pure material, such as 100 per cent acetylene, can enter the atmosphere. Vents may also supply essentially pure hydrocarbons, either continuously or intermittently. At flares, used to dispose of fuel-like materials, combustion is not always complete. Stacks release exhaust gases, rich in carbon monoxide and carbon dioxide, but also containing light hydrocarbons and other contaminants. At one location recently investigated, the stacks from gas-fired engines to drive compressors were found to contain an average of about 400 ppm of methane. Automobile exhausts have been studied and shown to contain as much as 12,000 ppm hydrocarbons (measured as hexane equivalent), 1100 ppm of acetylene, and 4000 ppm of oxides of nitrogen. In the absence of chemical analysis, the contribution to atmospheric pollution from a given source can be determined through process calculation of the reaction or stream to which the stack, vent, or flare is attached. Where nearby equipment is still in the planning stage, calculations will also predict anticipated waste contents.

Quite generally, the level of contamination at the effluence of a stack or vent is too high to tolerate at an air intake. The next question, obviously, is how far away must the air intake be located in order to be safe. This depends on two things. One is the plant's tolerance for impurities; or more specifically stated, the plant's capability for screening and expelling impurities effectively enough to prohibit hazardous levels within the plant. This tolerance depends upon the process cycle and the utilization of clean-up devices such as adsorbers. It will, therefore, vary from plant to plant, and must be analyzed separately for each plant and each location.

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AIR SEPARATION

4. ENVIRONMENTAL FACTORS (Contd)

c. Dispersion

The directional rate of dispersion of impurities is the other thing to consider in establishing safe distances from sources of contamination. If the surrounding air were always perfectly still and the impurities had the same molecular weight and temperature as the air, dispersion would follow a pattern approaching a spherical decay, that is, decreasing in concentration fairly rapidly and uniformly with distance. But, conditions as simple as these rarely exist, and dispersion of gaseous materials into the atmosphere is not so easy to predict. At times, when wind velocities are low, the molecular weight and effluent temperature of the contaminant itself control dispersion. Warm, light gases will tend to rise and disperse rapidly; cold, dense gases will tend to cling to the ground and dissipate slowly.

Sometimes, on calm days, climatic factors such as temperature and moisture content of the air will affect the pattern of dispersion. General air pollution levels may be seasonal in nature, and in some localities may vary from day to night, but at any given spot, where sources of pollution are available, the direction and velocity of the wind are of major significance in predicting contaminant levels. Generally speaking, pollutants will not travel upwind, and their dispersion rate increased with wind velocity. Therefore, the charts, previously mentioned, should indicate prevailing winds. To be very accurate, this wind data should be collected on the site, but information from a nearby weather station will be useful, especially if the station is within a few miles and if the terrain is relatively flat. Weather stations can provide a windrose, showing the yearly distribution of winds above 4 or 5 miles per hour on a percentage basis for each point of the compass.

Of course, since dispersion is a function of distance, the charts should also have a reasonably accurate scale.

In spite of all the variables, a qualitative picture of possible air contamination at a given point can be drawn by examining potential sources, the local wind pattern, and the distance to the proposed site, with special attention to desirable air intake locations.

Where sources of pullution are few and distant, the problem is reduced to optimizing plant layout—the generalized pattern calling for air intakes to be upwind of liquid storage and transfer areas, and of any stacks or vents associated with the plant complex.

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Page 5

AIR SEPARATION

4. ENVIRONMENTAL FACTORS (Contd)

d. Sampling

When evaluation of atmospheric conditions from a study of contaminant sources and wind data does not yield a clear-cut answer, more quantitative information should be obtained by air sampling and analysis on the proposed site. Ideally, continuous recording of levels of all suspected contaminants along with climatic variables, would provide the most reliable data. However, this is done only upon great incentive, for the expensive laboratory instruments having sufficient sensitivity to continuously analyze some of the pollutants of interest must be protected, sometimes even thermostated, and must be calibrated frequently. Both instruments and sampling trains require much attention by qualified personnel. Many instruments may be necessary to obtain the required data.

Hence, as a compromise, batch sampling and analysis is often employed. By referring to the charts, attempts can be made to sample under the most adverse conditions. Samples are then carried to a laboratory where they can be analyzed with a great variety of sensitive instruments.

However, batch sampling has its weaknesses. It may be necessary to wait months for the most adverse conditions to occur, and then circumstances which may yield one contaminant at its maximum level may not produce a maximum for another. If peaks of contamination are missed, batch sampling can be very misleading. Yet, all things taken into account, even the fact that new sources of impurities may appear before the plant is built on-site sampling and analysis is generally helpful in predicting atmospheric problems.

In summation, then evaluation of plant atmospheres can be accomplished by studying plans and charts of the surroundings showing not only equipment already existing. but also proposed equipment in relation to prevailing winds. When necessary, some on-site sampling may be done to provide additional information. Elements of doubt are covered by adding safety features in the plant cycle or by remote location of air intakes or relocation of vents and stacks which contribute to atmospheric pollution. The adequacy of the solution must then be verified during plant start-up and during the early months of operation by plant analysis. Plant analysis has reliability in that it represents what actually reaches vulnerable parts of the plant and is carried out while all auxiliary pieces of equipment are running. Any deviation from predicted performance based on the atmospheric evaluation should be carefully studied, and all lessons learned should be applied in solving future siting problems.

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605 PLANT SITE RITERIA

AIR SEPARATION

4. ENVIRONMENTAL FACTORS (Contd)

(2) Exposure to Hazards from Other Units

Any equipment, either within the plant complex or in the neighborhood, which represents a fire or explosion hazard or any other form of undue risk may be cause for rejection of a plant site. Fuel storage, fuel processing plants, and operations requiring combustion are cause for greatest concern. Imagine, if you will, an explosion in a petroleum tank farm area, followed by a fire fed from a liquid oxygen line ruptured by the explosion.

(3) Effect of the Plant on Surroundings

Heavy equipment, such as compressors, and high pressure vents, which are used frequently, can lead to noise problems affecting community relations. Used chemicals and oil condensate wastes present disposal problems requiring a solution before the proposed site can be considered acceptable. Of particular interest is the disposal of oxygen, especially if large liquid reservoirs are contained within or around the plant. The possibility of an accidental spill must be considered in relation to its effect on neighboring homes, industrial operations, roads, and sewer systems.

(4) Terrain

The site on which the plant is to be built must be capable of draining and, more important, it must not be a basin for drainage from other places. Soil conditions must be investigated so that heavy equipment can be supported without excessive vibration or without fear of ground settling, for vibrational fatigue of high pressure units or misalignment of high speed machinery can lead to acute safety problems.

(5) Climate

Is there an earthquake hazard? Is the site susceptible to flooding? Is it a hurricane or tornado area? Are there any sand or dust problems? Along sea coasts, salt in the atmosphere can deposit across insulators, causing serious electrical problems with high voltage equipment. Special process safeguards may be needed to compensate for equipment failures, resulting from excessively high or low ambient temperatures.

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4. ENVIRONMENTAL FACTORS (Contd)

(6) Fire and Police Protection

We must look at the time required to obtain outside assistance in the case of emergency. How far in time and distance is the nearest fire station? What is the quality of its equipment and personnel? Do water mains supply adequate volume and pressure for fire fighting? Where is the closest tie-in point to the main? Have seasonal water shortages become critical? Any deficiencies in these areas must be remedied; sometimes, at the cost of making the plant self-sufficient.

Although police protection is more closely related to security problems, police contact is often an integral part of an emergency procedure, especially in smaller plants at night, when operations may be carried out by very small crews.

(7) Access Roads and Communications

During the construction period and for normal operation, safe access roads will be essential. They must be capable of handling emergency traffic. Absence of alternate routes is a negative factor, if terrain features make the primary road susceptible to traffic interruption.

Telephones capabilities must be reviewed. The only line broken, an over-loaded switchborad, and other faults leading to delayed or interrupted service can intensify an emergency. Facility to tie into a fire alarm system is a desirable feature.

In reviewing the environmental factors which govern the selection of an oxygen plant site, we can readily observe that some warrant greater weight than others. A method of weighing them to reach a decision will be proposed after a short discussion of space factors.

5. SPACE

One reason we have talked so much about environment, and in particular the atmosphere which provides the raw material to the plant, is because through planning and by compensation within a plant site we can adapt to many environmental problems. Space requires much less discussion. Either we have it or we don't. Persistent safety problems and a rash of minor accidents can result from attempting to build a plant and to do business from a site which is too small for the purpose. Housekeeping invariably suffers, and poor housekeeping is often related to congestion; both breed accidents. A primary cause of congestion is the lack of storage space. Equipment which should be kept very carefully for future use in oxygen service may be difficult to protect because of lack of segregated space. Oils and chemicals required to run the operation will frequently be unnecessarily exposed.

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AIR SEPARATION

5. SPACE (Contd)

Aside from storage space, there must be sufficient operating and maintenance room. A plant designer must have the capability of arranging important controls and instruments so that they can be seen from a central operating area. He must also have the capability of mounting valves and other manual controls within easy reach of the operators. Space must be available for a maintenance area separate from the operating area. Not only from a safety standpoint, but from a sound operational standpoint, there must be sufficient space around units for removal of major components for maintenance.

Space is critical in the product storage and transfer area. Congestion on a cylinder dock leads to multiple shifting of bottles, to improper segregation, to the loss of aisles restricting access for handling equipment, and to increased difficulty in coping with an emergency. Have you ever seen cylinders stored to within inches of the edge of a loading dock several feet above the truck pad? Picture a man emulating a tight rope act along that edge because an aisle is blocked. If he starts to lose his balance, his first impulse is to reach for support from the nearest cylinder. Probability favors a fall for both man and cylinder.

At liquid stations, vents must have some degree of isolation. There must be room to grade the pad over which liquid is transferred, so that the drainage pattern can be controlled in the event of an accidental spill. Space must insure that vapors from excessive venting or spills do not reach air intakes, for oil-lubricated air compressors will react violently to an oxygen-rich diet.

Space provides the opportunity for safe movement of traffic within the plant gates and helps to eliminate material handling problems created by poor access to storage areas, to maintenance bays, and to product loading points. Even lack of parking space creates safety problems such as blocking of exits and restricting access to fire hydrants. For instance, a few years ago during an ammonia plant start-up, where more than the normal difficulties in lining-out equipment had been experienced, a critical acceptance run was beginning to look favorable, when a construction vehicle with a 10-foot high A-frame mounted on it found a roadway obstructed. The driver chose an alternate route under a 9-foot pipe rack supporting the instrument lines to the control area. Fortunately, the cost of damage could be reckoned only in time and money, no injuries.

Of course, another key space consideration related to industrial growth is the provision of room for expansion. Safety problems multiply when additional facilities are crammed into quarters already inadequate.

Space factors of interest, therefore, are related to:

- A. Storage and housekeeping
- B. Operation and maintenance

C.	Product	storage	and	transfer
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605 PLANT SITE CRITERIA

AIR SEPARATION

5. SPACE (Contd)

- D. Internal traffic problems
- E. Future expansion

Site modification to overcome lack of space is usually more difficult than compensation for negative environmental factors.

6. CONCLUSION

How, then, do we balance all of these factors relating to safety with the purely economic factors which must also be weighed to choose the best possible plant location? The answer lies in defining a level of safety-fixed within limits of judgement--which is to be invariant from one proposed location to another. Let's insist that the plant be adapted to the site to provide:

- A. Personnel safety, at least a little better than industry standards.
- B. Reasonable freedom from operating interruptions due to accidents.
- C. Immunity from persistent safety problems which portend minor hazards as well as continuously gnawing at our pocketbooks.

Safety standards now become an economic factor, with little flexibility. The cost of meeting these fixed standards at any given site can be equated directly with other economic factors. Very likely, an oxygen plant can be adapted to perform safely anywhere, but in extreme cases, estimated costs required to attain safety objectives may form a basis for site rejection. Upon acceptance, of the site, a real advantage in applying safety engineering in its selection becomes evident—the feature of having planned ahead. In any endeavor having standards we wish to attain or objectives we wish to meet, the goal can be reached more efficiently and more economically through careful planning. The plant safety program, therefore, has begun with a safety evaluation of the proposed site.

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AIR SEPARATION PLANT

LAYOUT

PURPOSE

This standard discusses the various aspects to be considered in a plant layout for air separation or low temperature plants.

2. SCOPE

This standard is concerned with the safety aspects of a plant layout.

3. GENERAL

Plant layout is a problem in space utilization. In part, it might be described as a compromise between conflicting requirements. The plant site must be large to accommodate plant hardware and all operating and maintenance activities; it must be kept reasonably small for economic reasons, for accessibility, and for ease of control. It is also a problem in arranging equipment with relation to other equipment and with the plant as a whole, and of grouping operating and maintenance activities for efficiency and ease of control.

This standard discusses the various aspects of plant layout from a safety standpoint, as space and its utilization and the arrangement of equipment have a direct bearing on the safe operation of the plant.

4. ACCESSIBILITY OF VALVES AND CONTROLS

The layout of the cold boxes, compressors, and auxilliary equipment must permit operator accessibility to all valves and controls required for normal and emergency operations. Equipment layout should be such that all valves and controls are accessible from working aisles.

Valves and controls requiring daily or frequent attention should be accessible from the normal working level. Valves required for defrost or shutdown purposes may be at higher elevations, but suitable working platforms must be provided.

Gauges, recorders, and indicators should be visible from the operating area, and should also be visible to the operator when manipulating key valves and controls.

Alarms should be visual and audible and be located so as to be visible from the operating area.

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1-6-61

605 CRITERIA

AIR SEPARATION PLANT

LAYOUT

5. LOCATION OF VENTS, DRAINS, AND DEFROST STACKS

All vents and drains from the air separation equipment should be located out of doors. Special consideration must be given to oxygen vents and cryogenic liquid drains.

Oxygen vents should be located to take full advantage of the prevailing winds to aid in dissipation of high oxygen concentrations. Since oxygen vapors, particularly when cold, but even at ambient temperatures, are heavier than air, oxygen vents should be elevated and, if possible, placed on the down-wind side of the plant. They should also be located so operating areas will not be exposed to high oxygen concentrations.

Cryogenic liquid drains should be located such that operating personnel will not be exposed to splashing or other contact with the cold liquids. A positive method of disposing of waste liquid should be provided.

Compressor blowdowns may be located indoors. The condensate, however, must be removed from the building separately from all oxygen lines or oxygen vents.

All safety valves, vents, and blowdowns discharging cold vapors should be located so that operating areas will not be obscured by fogs caused by the cold vapors. If necessary, safety valve vents should be headered to discharge away from operating aisles.

6. LOCATION OF AIR INTAKE

The location of the air intake is a critical factor to the safe operation of the plant. All possible sources of contamination should be studied. (Refer to the discussion on this subject in Section 605.1, Air Separation, Plant Site Criteria).

The location of the air intake should be coordinated with the various vents and blowdowns of the air plant itself. Possible high oxygen concentrations must be avoided, as fires and explosions are possible if high oxygen concentrations are drawn into an oil-lubricated compressor.

If at all possible, the air intake should be on the up-wind side of the plant. (There is at least one plant located in the middle of a refinery in which it was found necessary to provide two air intakes located 180 degrees from the air plant. The direction of the wind and the contaminant level in the intake air dictate which intake is used.)

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605 CRITERIA

AIR SEPARATION PLANT

LAYOUT

7. LOCATION OF OXYGEN LINES AND MANIFOLDS

In general, both oxidant and fuel lines should not be placed in the same pipe rack. Oxygen lines should not be placed in trenches, as a trench is a natural collecting spot for dirt and oil. If it is necessary to place oxygen lines in the same trench, tunnel, or duct, with fuel gas pipelines, good natural or forced ventilation must be provided and under no circumstances may the oxygen line be exposed to oil.

Fuel lines must be so located as to preclude any contact with liquid oxygen, as from a leaking liquid oxygen line, spill from storage or transfer equipment, or overflow from vents or safety valves.

Oxygen manifolds shall not be located in an acetylene generator room, or in close proximity to cylinders of combustible gases. Unless separated by a minimum of twenty feet, there shall be a fire resistive partition between the manifold and any combustible gas cylinders, or from highly flammable materials, such as oil or grease, or any substance which may cause or accelerate fire. A fire resistive partition may be considered to be one of the following types of construction, or other construction equivalent in strength and fire resistance:

- A. Gypsum or cement plaster at least 3/4 inch thick on metal lath on each side of a stud partition.
- B. Expanded metal lath encased in solid cement plaster not less than 2 1/2 inches thick.
- C. Reinforced concrete.
- D. Brick.
- E. Tile, gypsum, or concrete block (cement plaster on each side to a thickness of 1/4 inch).

Oxygen lines should not be run into or through the compressor building, unless it is necessary to pipe to a gaseous oxygen compressor.

If a central control room is provided, remote transmitters will be used:

- F. From any oxygen source with a pressure of 20 psig or more.
- G. From any other air, nitrogen, or other inert gas source of 100 psig or more.



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605 CRITERIA

AIR SEPARATION PLANT

LAYOUT

8. MAINTENANCE AND STORAGE

Good plant operating is impossible without space for storage of operating supplies and spare parts, and space for the performance of preventive and routine maintenance. Both the storage area and maintenance area should be separate from operating areas. The maintenance area should be so located that hot work (brazing, welding, etc.) will be possible without interference with, or from, normal plant operations.

The occasional necessity for the disassembly or removal of equipment should be kept in mind when equipment layout is being planned. This is particularly important around a compressor, where it may be necessary to pull a piston rod or a whole sylinder assembly, and around exchangers where bundles may have to be pulled.

A separate storage room should be provided for combustible supplies such as oils, lubricants, and paints. This storage room preferable should be outside the main buildings, but may be inside the compressor building against an outside wall. Design of the room should conform to N.F.P.A. Code 30, Section 70. Adequate separation must be provided between combustible storage area and the cold box, product storage areas, and oxygen vents.

9. PRODUCT STORAGE AND TOADING AREAS

Product storage areas should be separated from the operating plant as far as practicable, so that an emergency in one area will not involve the other. Adequate space must be provided for the maneuvering of liquid trailers, cylinder trailers, or other vehicles that must be accommodated. Product storage should, in general, se located toward the periphery of the plant layout.

Liquid storage sites must have, or be provided with, good drainage. Dikes are not recommended for orgogenic liquids. Liquid spills should be allowed to flow and dispense as much as possible to encourage rapid evaporation. Paving should be sloped to guide the flow of the spill, and curbing should be used where necessary to prevent the flow in an undesirable direction, as into sewers or toward process equipment.

10. ACCESS ROADS AND PARKING AREAS

Access roads should be laid out to accommodate not only the usual plant traffic, but also emergency equipment such as fire trucks and ambulances. If a circular pattern through the plant is not possible, adequate turnabouts must be provided.

Parking areas and access roads should be kept away from air intakes, as the exhaust from the trucks and automobiles will be contaminants in the process air.

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AIR SEPARATION PLANT

LAYOUT

11. LOCATION OF ELECTRICAL EQUIPMENT

While explosion-proof electrical equipment is not required in an air separation plant, electrical units should not be located in an area that may be subject to high concentrations of oxygen. Pumps, motors, and other electrical equipment that must be placed near the cold box or other sources of oxygen should be so located as to have good natural ventilation. If ventilation is difficult or impossible, as in a pit, inert gas purges to the instrument casing or motor housing should be provided.

In locating electrical equipment, it must be remembered that the equipment itself, the metal and insulating materials and finishes, will be the fuels for a potential fire. Operating temperatures of the equipment must be kept low and the oxygen content of the atmosphere should be kept below 25%.

12. WORKING PLATFORMS, STAIRS, AND LADDERS

Valves and controls required for the daily operation of the plant should be so located as to be operable from the ground or normal working elevation. If it is necessary to locate valves and controls at a higher elevation, stairs and working platforms, or ladders must be provided. If the operator must operate or otherwise maintain the equipment weekly or more frequently, stairs and working platforms should be provided. Otherwise, ladders may be used. Any ladder more than twenty feet high requires a cage.

13. FIRE MAINS AND EMERGENCY EQUIPMENT

The layout of fire mains and the location of hydrants, hose houses, fire extinguishers and other emergency equipment should not be undertaken until the location of all major equipment items has been firmly established. It will then be possible to make an analysis of the potential hazards and other safety problems throughout the plant and permit the location of emergency equipment to give maximum coverage.

A complete discussion of the fire protective and other emergency equipment that must be considered for a plant site can be found in the Industrial Safety Section of these Sarety Standards. The final selection of equipment and its location in the plant will depend upon several factors, the most important of which are:

- A. The type of plant to be constructed and the degree of hazard involved.
- B. Recommendations of the N.F.P.A. and N.B.F.U. as will be found in the publications of these associations.
- C. The recommendations of our insurers after their review of the detailed drawings.

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605 CRITERIA

AIR SEPARATION PLANT

LAYOUT

14. PROBLEMS IMPOSED BY CLIMATE AND TERRAIN

Initial plant layout should also consider any special problems imposed on the proposed site by the climate or the terrain. Of particular concern are the possibilities of flooding or of poor drainage after a severe storm. Abnormally high summer temperatures, low winter temperatures, prevailing wind direction, and abnormal conditions such as salt spray if near the sea coast should also be considered.

15. FUTURE EXPANSION

An attempt to expand a facility which has already reached its capacity from a space standpoint can only lead to ever increasing problems with housekeeping, personnel safety, and safe operations.

The potential for future expansion should be considered in the original layout. Adequate space should be provided for an expansion of equipment and production, based upon reasonable estimates of future sales potential.



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AIR SEPARATION

OXYGEN

COMPRESSOR

1. PURPOSE

This standard establishes the general safety requirements for oxygen compressor systems including materials selection, auxiliary equipment, instrumentation, location, cleaning procedures, and start-up of the equipment.

2. SCOPE

The standard defines requirements for all oxygen compressing systems designed or installed by Air Products and Chemicals, Inc. All systems must be approved by the APCI Machinery Engineering and Safety Departments prior to installation.

3. DESIGN CRITERIA

- A. Dry Oxygen Service (dew point -40°F or below)
 - (1) Compressor
 - a. Materials of Construction

Materials exposed to the process stream shall be compatible with high pressure oxygen. The use of carbon steel for surfaces exposed to oxygen is prohibited. All parts shall be identified as to material to permit an adequate engineering review.

b. Valves on Reciprocating Compressors

Compressor inlet and discharge valves shall not be interchangeable.

c. A suitable distance piece shall be provided to separate oil lubricated portions of the compressor from the oxygen stream with adequate ventilation and slingers provided.

(2) System Equipment

- a. Where the oxygen source is liquid or a possibility of liquid carry-over exists (storage tank flash recovery) the design of the suction piping shall provide a trap to prevent liquid carry-over into the compressor.
- b. Design Engineering Standards on piping shall be followed where carbon steel piping is provided on the suction side of the compressor with a stainless steel firebreak provided immediately adjacent to the compressor inlet.

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AIR SEPARATION

OXYGEN

COMPRESSOR

- 3. DESIGN CRITERIA (Cont'd)
 - A. Dry Oxygen Service (dew point -40°F or below) (Cont'd)
 - (2) System Equipment (Cont'd)
 - c. An adequately sized connection for a source of dry nitrogen or dry oil-free air (non-lubricated compressor) to the compressor suction shall be provided for start-up and run-in of the compressor.
 - d. Compressor discharge piping up-stream of interstage and aftercooler shall be copper, red brass, or stainless steel suitable for the pressures involved. Piping downstream of the coolers may be carbon steel with a stainless steel firebreak immediately adjacent to the next stage of compression. Maximum allowable velocities for carbon steel piping must be observed.
 - e. Where compressor bypass lines are provided, the bypass shall originate downstream of the cooler. The bypass may be carbon steel piping in accordance with the Design Engineering Standards piping section. The bypass control valve shall be stainless steel or copper alloy.
 - f. Flanges shall be provided for removing suction, interstage and discharge piping for inspection of the compressor system.
 - g. Intercoolers and aftercoolers shall utilize stainless steel, copper, or copper alloys for the inlet head, tubes and tube sheets. The discharge head may be carbon steel or cast iron subject to analysis and approval of velocity and impingement conditions.
 - h. Piping downstream of the aftercooler shall conform to the Design Engineering Standards, piping section.
 - i. A check valve shall be installed in a section of the discharge piping located remote from the oxygen compressor to prevent backflow of oxygen in the event of compressor failure.

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COMPRESSOR

3. DESIGN CRITERIA (Cont'd)

- A. Dry Oxygen Service (dew point -40°F or below) (Cont'd)
 - (2) System Equipment (Cont'd)
 - j. Discharge surge vessels on reciprocating compressors shall be stainless steel or copper alloy construction. Suction surge vessels may be carbon steel where velocity and impingement conditions are not severe. Corrosion resistant coatings, such as Kanigen plating, or equivalent, may be utilized for vessels when velocity or impingement is considered critical.
 - k. Stainless steel or copper alloy line strainers shall be provided in the suction piping of all compressor systems.
 - 1. Deviation from stainless steel or non-ferrous materials to corrosion resistant plated carbon steel, Kanigen or aluminized carbon steel, must be reviewed for approval by the Safety Department and the Chief Engineer's Office.
 - (3) Instrumentation

The following instrumentation shall be provided in the oxygen compressing system:

- a. Emergency Controls
 - /1/ A fail safe automatic block valve on the suction side of the compressor to close on compressor shutdown.
 - /2/ The following compressor shutdown devices are required and shall also close the automatic block valve:
 - /a/ A low temperature switch on the suction piping of any compressor taking suction from a possible cold source.
 - /b/ A low pressure switch on the suction piping of a compressing system.

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AIR SEPARATION

OXYGEN

COMPRESSOR

- 3. DESIGN CRITERIA (Cont'd)
 - A. Dry Oxygen Service (dew point -40°F or below) (Cont'd)
 - (3) Instrumentation (Cont'd)
 - a. Emergency Controls (Cont'd)

/2/ (Cont'd)

/c/ A high temperature switch on each stage discharge prior to the cooler. The maximum permissible setting on high temperature switches shall be:

Alarm 325° F Compressor Shutdown 350° F

Each location shall re-establish a lower setting when experience with operating temperatures indicates this is possible.

- /d/ A vibration switch on reciprocating piston compressor frames.
- /e/ A low oil pressure switch where applicable
- /3/ A minimum of two (2) emergency stop buttons shall be provided which will close the automatic block valve and shutdown the compressor(s). These shall be located in an area protected from the compressor by a minimum distance of 25 feet or by a masonry partition. A start-stop push button station shall be located adjacent to each compressor. Oxygen compressors on low pressure plants over 150 T/D shall have one stop button in the control room.
- b. Visual Indicators

All visual indicators shall be visible from the operator area, where practicable, and shall include:

/1/ A local dial type temperature indicator on the discharge of each compressor stage or centrifugal casing. A local temperature indicator at the inlet on each compressor stage or centrifugal casing having a 100 hp motor or larger.

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AIR SEPARATION

OXYGEN

COMPRESSOR

- DESIGN CRITERIA (Cont'd) 3.
 - Dry Oxygen Service (dew point -40°F or below) (Cont'd)
 - (3) Instrumentation (Cont'd)
 - b. Visual Indicators (Cont'd)
 - /2/ A pressure indicator on each stage discharge.
 - /3/ Each alarm and shutdown device shall be tied into an annunciator panel with an alarm in the compressor area, and, where practicable, a common visual indicator and alarm located in the control room.
 - c. Safety Valves

Safety valves shall be provided as required and shall be piped to the compressor suction or to an elevated vent outside the building.

- (4) Location
 - a. The oxygen compressor shall be located to minimize exposure to operating personnel and to associated equipment. Special consideration shall be given to isolation of compressors in the following instances:
 - /1/ Oxygen compressors on tonnage plants processing a major plant flow.
 - /2/ Small capacity compressors located adjacent to major equipment. The involvement of additional equipment in a large tonnage plant which could add to the exposure to personnel and equipment must be carefully evaluated.
 - Isolation of oxygen compressors, where required, may be provided by spacing of equipment, barricades, or a separate room. Where a separate room is provided, the installation shall include fire resistive materials of construction, two means of egress, panic hardware, and a ventilating system. The ventilating system shall have a failure alarm.

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607 PLANT COMPONENTS

AIR SEPARATION

OXYGEN

COMPRESSOR

- 3. DESIGN CRITERIA (Cont'd)
 - A. Dry Oxygen Service (dew point -40°F or below) (Cont'd)
 - (4) Location (Cont'd)
 - c. The method of preventing undue exposure to operating personnel by isolation of the oxygen compressor shall be subject to review of the applicable safety group (i.e., corporate Safety Department, APL Safety Office, etc.).
 - B. Wet Oxygen Service (dew point above -40°F)

On compressors processing wet oxygen or water solution lubricated oxygen compressors, all compressor system piping, valves, and associated vessels shall be stainless steel, copper, or copper alloys. The criteria listed in Part A is applicable except where contradictory to the above condition.

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1. PURPOSE

This standard provides information regarding the safety requirements to be met in the design and construction of cold boxes.

2. SCOPE

Cold boxes of all types are covered in regards to general safety considerations. Process equipment and piping are not included in this standard.

3. DESIGN REQUIREMENTS

A. Foundations

- (1) All cold box foundations must be a monolithic pour (i.e. a one piece construction).
- (2) A concrete apron shall extend a minimum of three feet out from the base line of cold boxes containing liquid oxygen. The LOX vaporizers shall be centrally located on an apron extending a minimum of ten feet from the base of the cold box having a minimum width of ten feet. A bed of clean gravel, or crushed stone shall extend from the concrete apron to maintain a minimum distance of twenty feet between asphalt roadways and cold boxes.
- (3) To prevent a heat leak through the foundation lowering the temperatures to a point where the earth beneath the foundation will freeze possibly causing a frost heave of the foundation, or lowering the temperatures to point which will materially affect the structural strength of the foundation; radiant heating coils shall be cast into the foundation 15 inches below the top face. Ample flow volume of effluent nitrogen must be provided to maintain outlet temperature at each coil exit of +35°F. To determine the extent of the heat leak and to determine the vertical temperature gradient through the foundation, three (3) thermocouples shall be cast in the foundation along a common vertical axis beneath the main cold box portion of the foundation.

B. Blowout Discs

For installation of Blowout Discs see Air Products and Chemicals, Inc. Design Engineering Standard 542.4.

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COLD BOXES

3. DEGICAL REQUIREMENTS (Cont'd)

C. Rockwool Purity

(1) In order to insure obtaining rockwool insulation having an oil content of 3.5 lbs. per ton or less, Standard 580.12.2.1 must be adhered to when procuring this material. The use of this standard will also provide qualifications for rockwool, which will not crush and crumble excessively during packing and repacking and thus keep the dust level to a minimum.

D. Process Equipment Separation

- (1) The following pieces of equipment should be isolated from the cold box.
 - a. All lubricated machinery shall be installed in a separate insulated box due to potential hazard of lubricating oil or oil mist leaks associated with these units.
 - b. Expanders, centrifugal and reciproceting shall be a minimum distance of 24 inches from cold box
 - c. The drive of the reciprotating organ pumps must be located external to the cold box.
 - d. Air-freon heat exchangers on plants above RD-2500 shall be installed external to the cold box either in their own jacketed enclosure or standing separate with molded insulation. An exception may be made to plants existing prior to the date of this standard where the subject exchanger is within the cold box. If it is practical and feasible, a sealed metal partition may be constructed to enclose the exchanger and isolate it from possible high oxygen concentrations. This enclosure must also be provided with a separate nitrogen purge outlet. Freon contains oil, picked up in the refrigeration compressor which would be dangerous in the event of a circuit leak.

E. Equipment Supports

(1) Wood and other combustible materials shall not be used inside cold boxes. Metal structural members or asbestos base material such as transite shall be used for supporting and bracing of piping and equipment.

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3. DESIGN REQUIREMENTS (Cont'd)

F. Electrical Equipment and Wiring

The policy concerning electrical equipment and wiring design, except thermocouple wiring, is governed by the plant size.

- (1) Standard plants up to 3500 CFH size
 - a. The electrical wiring to the freon circuits and to the liquid pump motors shall be external to the cold box. These connections can be run from the control panel directly to the equipment and kept outside of the cold box jacket.
 - b. The electric heater used for reactivation of the air driers may be mounted behind the jacket paneling, but the box containing the electrical connections to the heater should be made vapor tight by:
 - /1/ A continuous weld, sealing the box from the interior of the jacket.
 - /2/ The thermocouple wiring from the reactivation outlet from the driers should be sealed with lead where it passes through the box.
 - /3/ The heater shall be seal welded to the box. The electrical leads from the junction box to the heater shall run externally to the jacket. A louvered cover plate shall be used on the face of the box to prevent any oxygen accumulation inside.
- (2) Plants larger than 3500 CHF size
 - a. Electrical wires or elements may not be installed in cold boxes below an elevation of five feet. Above the 5-foot level, electrical wires and elements may be included only as an operational necessity and wiring (other than thermocouples) must be enclosed in an air tight conduit system with electrical equipment in a sealed appendage or sealed partition completely isolating the equipment from the cold box.

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- 3. DESIGN REQUIREMENTS (Cont'd)
 - F. Electrical Equipment and Wiring (Cont'd)
 - (2) Plants larger than 3500 CHF size (Cont'd)
 - b. Liquid oxygen sample vaporizers utilizing a heating element (for use with total hydrocarbon analyzers) shall not be located inside a cold box. Location shall be in an appendage to the cold box with a stainless steel partition seal welded between the cold box and the appendage.
 - G. In order to provide an adequate purge and the ability to increase this purge in case of leaks, the rules as listed below shall be followed in the design of the purge system and cold box jacket for oxygen plants. (Since a more critical problem is involved where hydrogen or other flammable gases are contained in process piping inside the cold box, a different set of rules is required for the purge system and cold box design, and is listed separately). If an adequate source of nitrogen is available at suitable pressure, it is not necessary to supply a blower specifically for this purpose, Adequate pressure should be construed as a minimum of 5 PSIG or, if the supply is large, for example, from the low pressure column, a minimum of 2 PSIG at the cutlet into the box should be sufficient.
 - (1) Oxygen plant purge system

The following design criteria shall be used on all future oxygen plants.

- a. The purge gas purity shall be a minimum of 90% nitrogen. The gas must be dry and oil free.
- b. The purge gas rate shall be a minimum of 2 SCFM per 1000 cu. ft. of box volume. Exclude equipment in calculating box volume. As an aid to quick estimating where box volumes may not be known, this purge rate is approximately 4 SCFM per 1000 SCFM air flow to plant.
- c. The source of purge gas on E 12,000 plants and larger shall be from the discharge of a nitrogen reactivation blower, preferably one which would normally be run nearly continuous without purge consideration. The purge rate should be added to the other flow requirements in sizing the blower. A typical set up for the purge system on a tonnage plant is shown below. The blower here would run continuously during normal operation.

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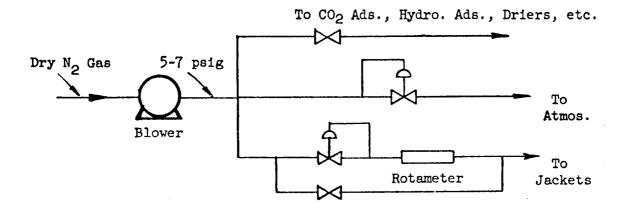
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3. DESIGN REQUIREMENTS (Cont'd)

G. Continued

- (1) Oxygen plant purge system (Cont'd)
 - c. Continued



A by-pass around the flow regulator and rotameter would provide for additional flow in case of internal oxygen leaks, etc.

- d. Most oxygen leaks tend to concentrate near ground level inside the cold box. About 80% of the purge outlets inside the jacket should be distributed evenly as near the base of the cold box as possible, the other 20% at higher elevations. Purge outlets should be provided near floor ground level close to all oxygen pumps. Purge lines should be sized to handle double the specified flow and should not be pinched at the end. If perlite is used as the box insulation, it will be necessary to add filters at each purge outlet.
- e. Couplings with plugs shall be provided on the cold boxes, (where openings such as removable panel bolt holes, and valve boots are not available), to permit the use of probes to detect oxygen leakage.

Location of the couplings shall be near floor level and at higher elevations that are susceptible to oxygen leaks, such as flanges on adsorbers, flanges on pump filters (on pump bores) etc.

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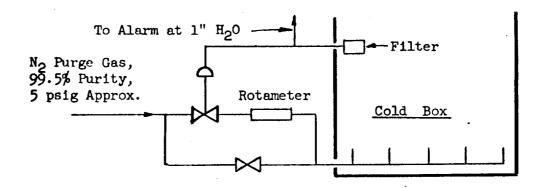
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3. DESIGN REQUIREMENTS (Cont'd)

G. Continued

- (2) Cold boxes containing hydrogen or other flammable gases.
 - a. The purge gas purity shall be a minimum of 99.5% nitrogen. (When nitrogen becomes un-available or economic consideration precludes its consideration, a waiver must be obtained from the Safety Department in these instances). The gas must be dry and oil free. The exact source of purge gas will not be specified due to the great variance in types of plants included here. However, the source should be at a pressure of at least 5 PSIG. The gas should be monitored for oxygen content or come from a source which is being monitored.
 - b. The purge gas rate shall be a minimum of 2 SCFM per 1000 cu. ft. of box volume. Exclude equipment in calculating box volume.
 - c. A manometer shall be provided to determine positive pressure on the box. The manometer should be located so that an operator can take readings of the pressure during a routine check of the plant. An alarm for low box pressure (1" of water) should be provided.
 - d. Rubber seal boots should not be used. Cold valve stems shall be attached to the cold box with gasketed seal plates.
 - e. The purge flow to the cold box jacket shall be piped as follows:



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3. DESIGN REQUIREMENTS (Cont'd)

G. Continued

(2) Continued

- f. Location of the purge outlets within the jacket should be determined after considering the density and the nature of the material to be handled. Special consideration should be given to locating purge outlets or tracers near cold lines or equipment which might condense air.
- g. Couplings with plugs shall be provided on cold boxes to permit the use of probes to detect process gas leakage. Location of couplings shall be at locations and elevations susceptible to gas leakage.
- h. A vent shall be provided at the center of the top of the highest section of the cold box. This vent shall be provided with a check valve or flapper to hold back pressure of three inches of water. The design shall be such as to prohibit air from entering the box through the vent. In the event that the box is constructed in a step-like fashion, that is with lower sections, an additional vent with a shut-off valve shall be provided on the top of the lower section. The valve can be opened if analytical sampling in the insulation indicates inadequate purge near the top of the lower section. When the box purge is a flammable gas the vent to the back pressure relief device shall be provided with a purge connection to permit purging with an inert gas. This inert purge can be used to reduce the possibility of a flammable mixture if the relief device developes a leak.

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FIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

2. PURPOSE

This standard establishes safety requirements concerning the design of piping, valves and safety valves in air separation plant equipment.

2. SCOPE

This information covers cold box piping, warm piping, oxygen transmission lines, valves, and safety relief devices in the design and operation of air separation plants. Portions of this standard are also applicable to cryogenic equipment other than air separation plants and distribution systems for gaseous and cryogenic liquid products.

3. GENERAL

The tensile strength of metals increases as the temperature decreases. However, many metals become brittle and their shock resistance so low at cryogenic temperatures that they may be broken by a sharp blow from a hand tool. This limits the number of metals that can be used safely in low temperature applications.

Piping design and selection of valves should be in accordance with Air Products and Chemicals, Inc. Design Engineering Standards, 570 Series specifications. Equipment not specifically designed for cryogenic service should not be used until it is checked completely for conformance with the applicable specifications for the intended service.

In general, the following two facts should be remembered:

- A. Carbon Steel should not be used below -20°F.
- B. Some metals that can be used safely below -20°F are:
 - (1) Austenitic stainless steel
 - (2) Aluminum
 - (3) Copper
 - (4) Monel
 - (5) Brass
 - (6) Silicon-Copper

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL

Carbon Steel lines are acceptable for dry gaseous oxygen service only within a restricted pressure, temperature, and velocity range. Carbon steel may be used providing (a) the maximum line pressure is less than 1000 PSIG (b) the temperature is within the range of $+250^{\circ}F$ to $-20^{\circ}F$, and (c) the velocity is 100 fps or less for pressures from 0 to 150 PSIG. For pressures above 150 PSIG, the maximum allowable velocity can be calculated by the equation $V_{\text{max}} = 100$ (165), where P is the proposed operating pressure (absolute).

These restrictions are based on the fact that (a) as pressure increases, the ignition temperature of carbon steel decreases, (b) carbon steel burns vigorously in a high oxygen atmosphere, and (c) as the pressure increases the drag on any metallic particle in the stream increases, thus increasing the friction of the particle and the possibility of its heating and igniting.

From the above it becomes apparent that the cleanliness of the pipe line before it is put into service and while it is in service is important. During construction every precaution must be taken to insure that the line is clean and free from all foreign material such as mill scale, rust, welding slag and icloses, oil and grease. After the line is installed and before it is put into service, the line should be completely hydrocarbon decontaminated with Tri-chloroethylene (or equal) or oakite solutions as described in the Air Products and Chemicals, Inc. Construction Specifications, Section 200. Alternatively, the system components may be cleaned prior to assembly, due care being taken that recontamination is avoided during assembly.

Carbon steel pipe may be used only if the baygen is dry, with a dew point below -40°F. Regardless of how clean the line is when originally installed, if water or water vapor is present, the formation of corrosion products will gradually produce the conditions that must be avoided. Also, corrosion and erosion will cause both localized and general reduction of pipe wall thickness, thus introducing the possibility of leaks and line rupture.

Stainless steel type 304 firebreaks, 30 inch long pipe sections of the proper wall thickness and diameter, should be welded into the line every 150 feet of run. All elbows, and tees where the entry is in the side part should also be stainless steel. In the event that the line should ignite, these stainless steel sections will stop the flame propagation.

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL (Cont'd)

For services where the pressure is greater than 1000 PSIG, where the velocity is greater than the allowable noted above, or water (or water vapor) is present, the transmission line must be of non-ferrous material or austenitic stainless steel. Pressure will be limited only by the design properties of the material being used and velocity limited only by good design practice and the avadlable pressure drop.

A. Gaseous Oxygen Transmission Lines

The design of gaseous oxygen transmission lines shall incorporate the following design criteria:

- (1) A periodic inspection of transmission lines is advisable and, therefore, it is preferable to install transmission lines above grade.
- (2) Welded or silver brazed joints shall be used wherever possible to minimize the possibility of leakage.

 Mechanical joints are not permitted in buried transmission lines.
- (3) Oxygen transmission lines are permitted in pipe trenches, ducts, and tunnels containing flammable gas lines only if adequate ventilation is available. Oxygen lines are not permitted in pipe trenches, ducts, and tunnels containing piped flammable liquids or where oxygen leakage may contact oil.
- (4) Oxygen and flammable gas transmission lines located in filled trenches shall be maintained a minimum distance of 18 inches between the exterior surface of the lines. If the lines are encased in concrete, a minimum distance of 12 inches shall be maintained.
- (5) Transmission lines should be located away from source of heat, power lines and vibration.
- (6) Oxygen supplied by a vaporizer to carbon steel piping shall be provided with a low temperature actuated control valve at unattended facilities. Attended (24 hours per day) facilities may be provided with a low temperature alarm in lieu of the above control valve.

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GOT PLANT COMPONENTS

AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF TO VID

4. PIPING, GENERAL (Cont'd)

- A. Gaseous Oxygen Transmission Lines (Cont'd)
 - (7) In oxygen transmission lines where the use point is not under the direct control of the air plant operators, or where, due to a long or extensive transmission system. there is exposure to rupture or damage from outside sources such as road repair, excavation, heavy equipment, etc., automatic shut off valves should be installed immediately downstream of the last source of supply. This shut off valve should be designed to close under excess flow conditions as would result in a major failure of the transmission system.
 - (8) Protection should be provided against physical damage where this may occur due to vehicular traffic. Compliance with local codes on this subject must be determined.
 - a. Underground lines under roadways shall be encased in suitable pipe sleeves.
 - b. Underground piping leading to the surface shall be protected by guard posts or similar methods to prevent accidental rupture of the line.
 - (9) Underground piping shall be provided with block valves such that periodic leak tests may be made by holding the appropriate pressure in the line for a minimum of one hour. Normally a block valve at each end of the line will be adequate to isolate the line from the equipment for the leak test.
 - (10) In some locations it may be necessary to provide a sand bed or other porous bed to improve drainage when designing underground oxygen piping.
 - (11) Buried transmission lines shall be located below the frost line.
 - (12) Buried transmission lines shall have low point drains provided as required.
 - (13) The exterior surface of buried carbon steel piping shall be protected by applying a corrosion resistant coating as approved by the Safety Department (see Safety Standard 609.1).

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL (Cont'd)

- A. Gaseous Oxygen Transmission Lines (Cont'd)
 - (14) Pressure test of piping systems shall be made at 1.25 times the design pressure with dry oil-free (non-lubricated blower) air or nitrogen and all weld shall be soap tested.
 - (15) All threaded joints shall be made with teflon tape as listed in Safety Standard 609.1.
- B. Cold Box and Warm Piping
 - (1) General
 - a. Carbon steel process piping is prohibited within a cold box, except for the RD Series Plants; and the small military units where the air driers and the associated piping is placed within the cold boxes.
 - b. Low temperature alarms or low temperature switches activating automatic block valves shall be provided in carbon steel piping where temperatures below -20°F may be reached during plant upsets or steam failure on vaporizing systems.
 - c. Carbon steel warm piping shall be designed to maintain the following distances between parallel piping:
 - /1/ Oxygen piping shall be a minimum distance of three times the OD of the pipe or on large pipe sizes not less than 12 inches from adjacent oxygen piping.
 - /2/ Oxygen piping shall be a minimum distance of 18 inches from flammable gas piping except at the use point where these lines are combined.

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

- 4. PIPING, GENERAL (Cont'd)
 - B. Cold Box and Warm Piping (Cont'd)
 - (1) General (Cont'd)
 - d. Allowances in interconnecting piping shall be made for vessel contraction when comparing the erected condition to the operation condition.
 - e. The most reliable (leak-proof) joint shall be used in all piping. Flanges are to be avoided wherever possible, particularly in cold box piping. Where flanges cannot be avoided, they should be prepared and installed in accordance with the application section of the Design Engineering Standards.
 - f. Heaters for use with all types of driers and adsorbers shall be located external to the jacket on E-2500 plants and larger; and as close to the vessel as possible to insure an adequate reactivation temperature. This is particularly important in oil adsorber systems.
 - g. Liquid oxygen sample vaporizers (for use with total hydrocarbon analyzers) shall not be located inside the cold box. Location shall be in an appendage to the box with a sealed partition between the cold box and this appendage.
 - h. Air-freon heat exchangers on plants above RD 2500 shall be installed external to the cold box, either in their own jacketed enclosure or standing separate with molded insulation. (An exception may be made to plants where the subject exchanger is within the cold box. If it is practical and possible, a sealed metal partition may be constructed to enclose the exchanger and isolate it from possible high oxygen concentration. This enclosure must also be provided with a separate nitrogen purge outlet).

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

- 4. PIPING, GENERAL (Cont'd)
 - B. Cold Box and Warm Piping (Cont'd)
 - (1) General (Cont'd)
 - i. Where two or more reboilers are required for a single plant or where partition plates are provided on a single reboiler, care should be exercised that the oxygen outlet piping is so arranged that liquid cannot flow back to either an isolated condenser or isolated portion of a single unit. This can be assured by manifolding the two lines at an elevation below that of the inverts of the oxygen outlet branches.
 - j. Hydrocarbon adsorber bypasses shall not be provided in the design of new plants
 - k. A valve system utilizing a double block and bleed shall be provided on reactivation lines to equipment containing oxygen enriched atmosphere i.e. hydrocarbon adsorbers, oxygen compressor driers, and centrifugal liquid oxygen pumps (for heated defrost). A check valve shall be provided in the drier reactivation line.
 - 1. Defrost, Disposal and Reactivation Drain Lines and Stacks.
 - /1/ The chart below should be used as a guide in piping to stacks.

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AIR SEPARATION PLANT	PIPING, VALVES AND SAFETY RELIEF DEVICES			
4. PIPING, GENERAL (Cont'd)				
B. Cold Box and Warm Piping (Co	nt'd)			
(1) General (Cont'd)				,
1. (Cont'd)				ŀ
/1/ (Cont'd)				
Plant Size	Oxygen Vaporizer Disposal Stack	Plant Defrost Stack	Exchanger Defrost Stack	Local Vent Outside Building
Standard Plants				
LP Column Defrost Condenser Defrost All other defrost and reactivation lines	x x		•	x
			•	
LP Column Defrost Condenser Defrost Hydrocarbon Adsorber Reactivation HP Column * Heat Exchanger Defrost All Other Defrost Lines Reactivation Lines	x x x	x x x		x
Tonnage Plants				
LP Column Defrost Condenser Defrost Pure Oxygen Subcooler Defrost Centrifugal Plant Pump Defrost HP Column * Heat Exchanger Defrost (Air Side) Drier Reactivation	x x x	x	x	x
Hydrocarbon Adsorber Reactivation Carbon Dioxide Adsorbers All Other Defrost Outlets Regenerator Vents		x x x	•	x
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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

- 4. PIPING, GENERAL (Cont'd)
 - B. Cold Box and Warm Piping (Cont'd)
 - (1) General (Cont'd)
 - 1. (Cont'd)

/1/ (Cont'd)

- * NOTE: Liquid from the high pressure column will be dumped into the low pressure column. When all liquid is removed from the high pressure column the defrost gas should be vented to the stack indicated.
 - /2/ The location of all vent stacks should be selected to take best advantage of prevailing winds. Discharges from the oxygen defrost stack must not be permitted to be drawn into the air intake to the compressors or into any building ventilation system. Every effort should be made to keep the cold vapors out of the operating areas where the fog will obscure operator visibility and the increased oxygen concentration will present a fire hazard.
 - /3/ The oxygen vaporizer disposal stack and plant defrost stack shall be located at an elevation based on the following criteria to insure adequate dispersion of venting gases:
 - //a// A minimum of five feet above the eaves
 of a nearby building.
 - //b// A minimum of five feet above an adjacent cold box; or, for cold boxes over 60 feet in height, a minimum height of 50 feet above grade when natural ventilation to the stack is not obstructed and a minimum height of 20 feet above operating platforms and walkways.
 - /4/ An exchanger defrost stack shall be elevated to a minimum of 30 feet above grade and a minimum of 15 feet above operating platforms and walkways.

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL (Cont'd)

- B. Cold Box and Warm Piping (Cont'd)
 - (1) General (Cont'd)
 - 1. (Cont'd)
 - /5/ The stack shall be provided with a flat bottom head installed 30° to the horizontal with a 1/2 inch drain valve or other low point drain means to prevent the accumulation of rain and condensate and to permit solvent washing the stack. A suitable weep hole should be drilled in the stack beneath this head.
 - /6/ Materials used for the oxygen disposal stack must be compatible with liquid service for the full height.
 - /7/ A tee section, the same diameter as the stack, with the ends beveled at 45° to prevent rain from blowing in should be used at the top.
 - /8/ Safety valves venting liquid or gaseous oxygen should be piped to the oxygen disposal stack where practicable.

m. Purge Piping

Purge outlets in an oxygen cold box should be located such that 80 per cent are as near the base as possible and 20 per cent higher up in the box. The location of purge outlets on flammable gas boxes shall be determined by the density of the gas. Refer to Safety Standard 617.1.5 for a complete discussion of purge piping in cold boxes.

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Approved: Safety Director

Date

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL (Cont'd)

C. Safety Valves and Rupture Discs

Safety valves should be included on all process and mechanical equipment as dictated by good design and the applicable codes and specifications. Material, capacity, and type of design must be compatible with the service intended.

Particular attention should be given to the location of safety valves in the cold sections of the plant. Process safety valves must, of course, be provided to vent the full process flow in the event of a plant upset. Thermal relief valves must be provided on all vessels and sections of pipe not otherwise protected by safety valves and rupture discs, in which cryogenic liquids may le trapped by closing off valves. Oxygen, for example, if vaporized and heated from a liquid at atmospheric pressure to a gas at 70°F and one atmosphere will expand in volume 859 times. If the volume were held constant, as would be the case of liquid trapped in a pipe line, the pressure could increase 859 times. For example, if the initial pressure were 75 PSIG (high pressure column operating pressure), the final pressure would be approximately 77,000 PSIG, which is far in excess of the ultimate strength of the equipment. A thermal relief valve properly located will bleed off this excess pressure as it develops, thus protecting the process equipment from dangerous overpressuring.

Rupture discs should always be located in a warm zone or on a warm leg. Rupture discs are designed to break at a specific pressure at a specific temperature. The tensile strength of the disc and thus the pressure at which it will rupture is affected directly by the temperature. As the temperature is lowered, the rupture pressure may increase as much as 20 per cent to 100 per cent depending on the material used and the temperature to which it is cooled. Placing the safety head in a warm zone or on an adequately designed warm-up leg will limit the temperature variations to that of the ambient condition or to minor process fluctuations.

Safety devices, once installed and placed in operation, should be inspected and tested periodically. Some valves, such as the process safety valves on the high and low pressure columns may blow from time to time due to process fluctuations or during start-up and operation, therefore release pressure, reseating pressure and leakage are readily checked. Other valves, such as the thermal relief valves, may not be used from one year to the next. Under these conditions, it is possible for the valves to freeze due to accumulation of dirt and rust thereby failing to operate properly.

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PIPING, VALVES AND SAFETY RELIEF DEVICES

4. PIPING, GENERAL (Cont'd)

C. Safety Valves and Rupture Discs (Cont'd)

Testing in place by a controlled increase of the operating pressure is adequate, if the test is properly supervised and recorded. Otherwise, the valve should be removed from the process equipment, inspected, cleaned and repaired as necessary, and pressure tested.

Installation of safety valves should be made with the following considerations:

- (1) Personnel and equipment must not be exposed to the hazard of high velocity gas discharge and/or cryogenic liquid spray.
- (2) All safety valves installed outdoors subject to freezing climatic conditions must be protected against the entrance of water, snow and ice in the internal parts. Also, for large safety valves, a screen should be provided to prevent entrance of objects such as birds, etc.
- (3) All safety valves must be installed with the spindle in a vertical position, with the inlet at the bottom.
- (4) Safety valves can be divided into two groups; those which originate from insulated cold boxes and piping and all others which are protecting warm equipment and piping.
 - a. Cold Box Safety Valves
 - /1/ The discharge piping from the safety valves must be carefully sized to prevent excessive back pressure on the valve.
 - /2/ Safety valve inlet lines from partially gas filled lines shall branch off the top of the process line and be run vertically upward before being run horizontally. The horizontal position shall extend from the cold zone to the warm zone (within three inches or four inches of the jacket) before turning vertically downward. Where a safety valve is to be located above its point of take-off, no additional rise in elevation will be necessary in order to create an inverted seal. An adequate warm-up leg and flexibility run will still be necessary.

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

- 4. PIPING, GENERAL (Cont'd)
 - C. Safety Valves and Rupture Discs (Cont'd)
 - (4) (Cont'd)
 - a. Cold Box Safety Valves (Cont'd)
 - /3/ All safety valves must be located external to the jacket and be readily accessible for maintenance.
 - /4/ Care is to be exercised that all cold piping lines between shut-off valves have thermal relief protection provided by a safety valve.
 - b. Warm Equipment Safety Valves

Safety valves protecting warm equipment and thermal relief valves may not require piping from the discharge port but care must be taken to properly orient this port to avoid pointing in the direction of operating areas, aisles, etc. Refer to Design Engineering Standard 537.1.

- D. Instrument Piping
 - (1) Instrument piping external to a cold box shall conform to Design Engineering Standards 530. That is, limitations on instrument lines up to 3/8 inch OD are: (1) copper tubing with compression (flareless) fittings up to a maximum pressure of 1500 psig and (2) stainless steel tubing and approved flared fittings up to a maximum pressure of 3500 psig.

Instrument piping internal to the cold box is designed in accordance with Design Engineering Standard 570 and includes tubing originating in the cold box to the first shut-off valve on remote instruments or to local panel mounted instruments.

On lines above 3/8 inch OD to a maximum of one inch OD, internal or external to the cold box, pressure limitations shall be more stringent and the application must be checked by the appropriate Design Group, Instrument or Piping.

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AIR SEPARATION PLANT

PIPING, VALVES AND SAFETY RELIEF DEVICES

- 4. PIPING, GENERAL (Cont'd)
 - D. Instrument Piping (Cont'd)
 - (2) Air and inert gases over 100 PSIG and oxygen over 20 PSIG shall be eliminated from control rooms by the use of transmitters.
 - (3) Bleed valves shall be installed on all instrument lines 120 PSIG and over (normal operating pressure) between the shut-off valve and the instrument.

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AIR SEPARATION PLANT

CRYOGENIC LIQUID

DISPOSAL

1. PURPOSE

This standard discusses acceptable methods for the disposal of the cryogenic liquid hold-up in the columns and reboiler in the event of excessive contamination and to expedite plant defrost procedures.

2. SCOPE

Every air separation plant except the small military plants (one ton capacity and smaller) shall be provided with an acceptable cryogenic liquid disposal system.

3. GENERAL

A problem inherent with every air plant shutdown or defrost is the disposal of the liquid from the columns, the reboiler, and the interconnecting cold box piping. Fast, safe disposal of this liquid means faster turnarounds and less lost production time.

The magnitude of this disposal problem is indicated by the following tabulation of the liquid hold-up in several typical plants.

Cryogenic	Liquid	Hold-up

Plant Size	Gallons	Tons
E-2500	30	
E-12,000	290	1
25 T/D	750	3.5
75 T/D	1,550	7.5
150 T/D	3,560	17
350 T/D	8,500	41

Safe disposal of this liquid entails protection of personnel and equipment from contact with the liquid or possible high oxygen atmospheres, and also disposal in such a manner that any contaminants present do not concentrate as the liquid vaporizes.

4. DISPOSAL VAPORIZERS, STEAM

Vaporizer heat exchangers, are the preferred method for disposal of waste cryogenic liquids. Using a vaporizer there is no possibility of exposure to cryogenic liquids, as the cold liquid and gases are contained in a closed system until vented at a high elevation. Another important feature is that any contaminants in the liquid will vaporize essentially at the same time as the liquid. This precludes the possibility of contaminant concentration as may occur when using a dump tank or to a lesser extent when dumping into an open field.

Originated By:

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607 PLANT COMPONENTS

AIR SEPARATION PLANT

CRYOGENIC LIQUID

DISPOSAL

4. DISPOSAL VAPORIZERS, STEAM (Cont'd)

The flow sketch and design specifications for a vaporizer suitable for disposal of cryogenic liquid from tonnage plants is included in Design Engineering Standard 514.6.2. This unit was sized to gravity drain a 150 T/D plant in two hours. Using it on other size plants will change the draining time by a ratio of the plant size.

In order to keep the pressure drop down to 5 psi, the cryogenic liquid from this vaporizer is vented as a cold gas. Since the vaporizer may be located in the operating area adjacent to the cold boxes, it may be vented to the main plant defrost stack. If the plant layout prohibits the use of the main defrost stack, a separate stack must be provided which must be sufficiently high or remotely located to prevent fogging the operating area or exposing personnel to high oxygen gas concentrations.

5. DISPOSAL VAPORIZERS, WATER

A water vaporizer for standard plants (E-12,000 size and smaller) is described in Design Engineering Standard 514.6.2. Again, if the main defrost stack is used for the vent gases or if another high or remotely located stack is provided, the vaporizer may be located near the cold box.

If water is not available, this unit can be converted to air heating by using the coil without the tank and a suitable fan for forced draft. Additional capacity can also be obtained by increasing the tube length by adding 50-foot lengths of tubing.

6. DISPOSAL AREAS, NATURAL

Some plants are fortunately located near a natural site that can be used for cryogenic liquid disposal. In these instances the air plants are on the periphery of, or well away from, other industrial activities. At several locations large open fields are adjacent to the plants and the liquid can be piped to a diked area and allowed to vaporize. This disposal area must be kept clean. It is imperative that organic materials such as hydrocarbons, vegetation, wood products, and other refuse be kept out of the diked area and also from the surrounding area for a distance of at least 50 feet.

When considering a site for liquid disposal, the possibility of exposing personnel, the air plant itself, or other nearby activities or equipment to cryogenic liquids or high concentrations of gaseous oxygen must be considered carefully. Since the cold oxygen vapors will be considerably heavier than air, they will tend to cling to the ground, and disperse slowly unless a brisk breeze is blowing. Even so, depending on the quantity of liquid being dumped, clouds of vapor and concentration of oxygen will carry downwind for some distance.

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AIR SEPARATION PLANT

CRYOGENIC LIQUID

DISPOSAL

6. DISPOSAL AREAS, NATURAL (Cont'd)

A lake, large pond, or reservoir is a better disposal area than an open field. The water provides a large heat sink for vaporizing the liquid and cleanliness is rarely a problem. The precautions noted above must be taken to protect personnel and equipment against exposure to cryogenic liquids or high oxygen or other gas exposure.

Air Products

Originated By:

H. Smith

Approved: Safety Director

L. Ball

Date

STORAGE

CONVERTER SYSTEM

CRYOGENIC LIQUIDS

1. PURPOSE

This safety standard describes the design features required for the Cryogenic Liquid Converter System.

2. SCOPE

This safety standard encompasses basically the area in and around the Cryogenic Liquid Storage area and the Liquid Tanker transfer area of an I & M Division site, but may apply to any similar site.

3. GENERAL

Liquid storage and vaporization systems as are now being installed by our I & M Division are relatively small and compact. As they require a minimum of space there may be a tendency to install these units in any available space as long as access is available by the liquid tanker. However, potential exposure of customer and third party equipment and personnel to our equipment and possible leakage or spillage of cryogenic liquid must be carefully evaluated before a site is approved.

As the storage tank, vaporizer and related piping and control system have been carefully engineered, manufactured and tested, the probability of a major equipment failure is very remote. Leaks that might develop, such as at flanges or welds, will be small and can be controlled and repaired comparatively quickly and easily.

The major hazard exists during the period transfer of liquid from a tanker to the storage tank. A hose or system failure at this time can and has resulted in the dumping of large quantities of liquid.

To insure that each liquid storage and vaporization system is installed in a safe location, the following design features shall be used.

4. DESIGN FEATURES

- A. Liquid Oxygen Storage and Vaporization Systems
 - (1) A concrete pad shall be installed under the storage tank. The vaporization system may be installed on concrete piers on footings, separate from the pad and curbs.
 - (2) A concrete wheel stop shall be installed to prevent backing the tanker into the storage tank, vaporizer or piping. The wheel stop may be a part of the curbing.

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STORAGE

CONVERTER SYSTEM

CRYOGENIC LIQUIDS

4. DESIGN FEATURES (Cont'd)

- A. Liquid Oxygen Storage and Vaporization Systems
 - (3) A concrete curb shall be installed around the pad to contain accidental spillage during loading operations. Curb and wheel stop should be so arranged that hose connections and trailer vent will be located inside the curbed area during loading and operations. Curbed area requires a drain which normally should be stoppered but can be opened to drain water accumulations. In the event of a major spillage, overflow from the curbed area should be controlled toward the safest direction. Curbing should be used to control flow of spilled liquid toward a safe disposal area if such area is available.
 - (4) If space limitations prevent positioning the tanker as noted in 4,A,(3), a concrete apron should be provided in front of the curbed area sloped toward the curbed area and of sufficient size to control nominal spillage.
 - (5) Major spillages, such as dumping all or part of a tanker load of oxygen have occurred. Each proposed site must be analyzed for involvement of customer or third party property and personnel in this eventuality. Our tankers do not have excess flow valves, so if conditions arise where the block valves are open and cannot be operated, or the lines are broken between the block valve and the tank, the tank contents will be dumped. An attempt to move the tanker to a safer location with oxygen flowing from a broken or open line could be hazardous as starting or operating the tractor engine in a high oxygen concentration could ignite oil and dirt accumulations on the engine or undercarriage of the tractor or trailer. Spillage of LOX on the highway and possible into sewers would present additional hazards. Storage tanks should be located such that major spills can be directed into a relatively safe area where it can evaporate and disperse. Sewers must be avoided as well as exposure of customer equipment and personnel.
 - (6) Fencing should be provided about both the storage tank and the vaporizer if there is exposure to the general public. If the system is inside an industrial complex or otherwise fenced-in area, fencing about the storage system may not be required.
- B. Liquid Nitrogen and Argon Storage and Vaporization Systems
 - (1) Liquified inert gas storage tanks need not, for safety reasons, be erected on concrete pads. Concrete piers or footers as required for structural purposes are sufficient.

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SAFETY STANDARDS

607.2.1.1 Page 3

607 PLANT COMPONENTS

STORAGE

CONVERTER SYSTEM

CRYOGENIC LIQUIDS

4. DESIGN FEATURES (Cont'd)

- B. Liquid Nitrogen and Argon Storage and Vaporization Systems
 - (2) Proposed locations should be reviewed for potential exposure of personnel and equipment to cryogenic liquids and temperatures and curbing installed if necessary to control flow of liquid toward safe disposal areas.
 - (3) Fencing should be provided about both the storage tank and vaporizer if there is exposure to the general public. If the system is inside an industrial complex or otherwise fenced-in area, fencing about the storage system may not be required.

Air Products

Originated By:

Approved: Safety Director

Date

W. L. Ball

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April, 1962

STORAGE

VACUUM SYSTEMS

COMPRESSED GASES

1. PURPOSE

This standard establishes uniform safety requirements for vacuum systems used to evacuate compressed gas cylinders and tube trailers.

2. SCOPE

The data contained herein applies to all Air Products and Chemicals, Inc. nonflammable compressed gas cylinder charging and recharging facilities.

3. GENERAL

- A. Separate evacuation systems must be provided for oxygen cylinders and inert cylinders. See Figure 607.2.2.5-1 and Figure 607.2.2.5-2.
- B. The evacuation system for the inert gases can be divided into two distinct manifold functions; water or dry pumped gases and oil pumped gases. See Figure 607.2.2.5-2.
- C. Safeguards must be designed into cylinder charging manifolds to:
 - (1) Prevent overpressurization of the vacuum system in the event of misoperation of the manifold system.
 - (2) Prevent the backflow of air, oil vapors, and vacuum pump lubricant from entering the manifolds in case of misoperation of the vacuum system.
- D. Solenoid valves, vacuum line safety vent, vacuum line vent valve, and vacuum line surge vessel will be devices used to accomplish the safeguards as required by Subject 3. GENERAL, Paragraph "C".

4. SOLENOID VALVES

Two solenoid valves are required to supply the protection needed in the vacuum system; one in the vacuum pump oil line between the oil reservoir and the pump case, and the other in the suction line to the vacuum pump. Both valves which close upon the loss of electric power are wired into the vacuum pump motor starting switch. The valves will provide protection against air and oil entering the manifolds through the vacuum pump. Solenoid valve seat material will be metal to metal or if soft seat material is used, the material should be compatible with the vacuum pump lubricant used. Teflon or Kel-F is acceptable material for use with the lubricants listed in this standard.

APCI DOCUMENT NO 99 00 00 49

607 PLANT COMPONENTS

STORAGE

VACUUM SYSTEMS

COMPRESSED GASES

5. VACUUM PIPING VENT

To prevent overpressurization of the vacuum piping system, install a vent assembly in the suction line near the vacuum pump between the manifolds and the suction solenoid valve. The vent is mounted vertically in the vacuum piping. Sketches of vacuum pump line vents are shown in Figure 607.2.2.5-3 and Figure 607.2.2.5-4.

6. VACUUM LINE VENT VALVE

A vent valve installed between the solenoid shut-off valve and the pump will be opened to break the vacuum in that part of the system whenever the pump is not operated.

7. VACUUM LINE SURGE VESSEL

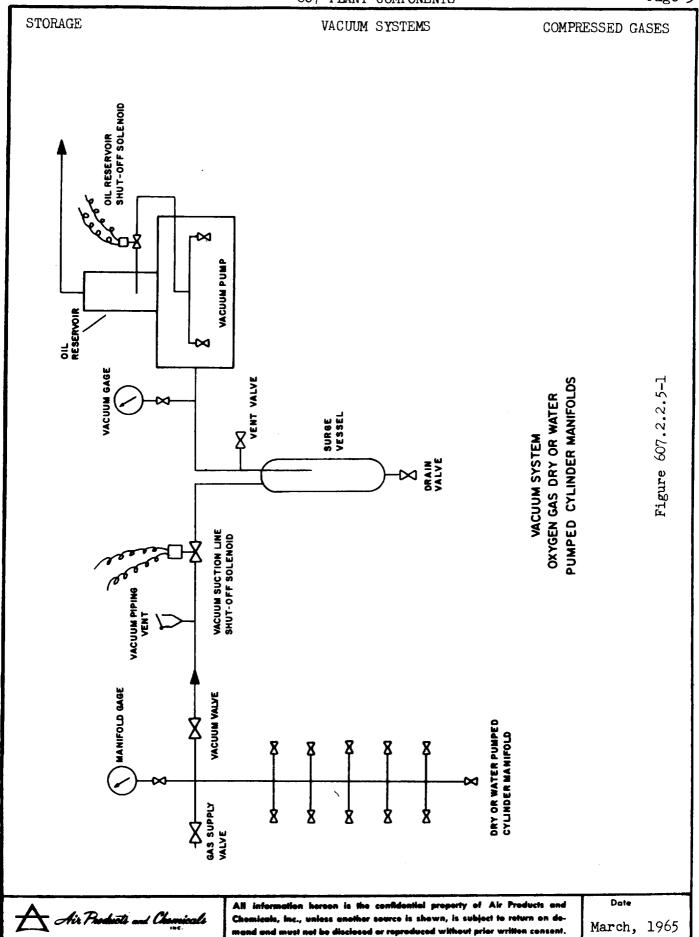
A vessel mounted in the vacuum line between the solenoid shut-off valve and the pump will serve as a collecting vessel for oil in the event of malfunction of the system to minimize the possibility of oil entering the manifolds. The vessel may be an old cylinder or a large section of pipe mounted vertically in the line.

8. VACUUM PUMP LUBRICATION

Two lubricants are acceptable for vacuum pump service; tricresylphosphate (TCP) and Cellulube 220. Although neither lubricant is completely compatible with oxygen, they represent a lesser hazard when compared with hydrocarbon lubricants. TCP is less sensitive to impact than Cellulube 220; however, Cellulube 220 has a higher flash and autoignition point than TCP.

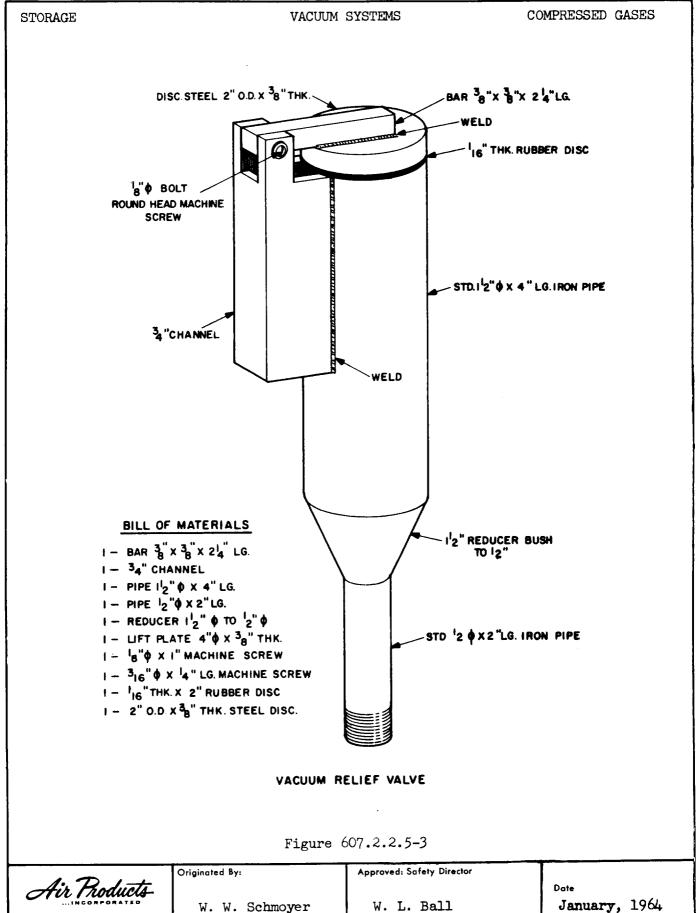
TCP is toxic through ingestion, inhalation, and skin absorption. Cellulube 220, although no toxic cases have been reported, should be handled as carefully as TCP. Some precautions to minimize personnel exposure when handling or using these lubricants are:

- (1) Wear rubber or plastic gloves.
- (2) Do not smoke.
- (3) Wash hands after using.
- (4) Pipe vacuum pump exhaust outside of buildings.



607 PLANT COMPONENTS

Page 4 COMPRESSED GASES STORAGE VACUUM SYSTEMS GAS SUPPLY
VALVE OIL PUMPED CYLINDER MANIFOLD VACUUM X X Ø VACUUM PUMP OIL RESERVOR FOR INERT GAS DRY OR WATER AND OIL PUMPED CYLINDER MANIFOLDS Figure 607.2.2.5-2 VENT VALVE WCUUM GABE SURGE Vessel VACUUM SYSTEM DRAIN VALVE VACUUM SUCTION LINE SHUT-OFF SOLENOID VACUUM PIPING MANIFOLD GAGE VACUUM VALVE DAY OR WATER PUMPED CYLINDER MANIFOLD 6AS SUPPLY WALVE Air Products and Chamicals March, 1965 ed and must not be disclosed or reproduced without prior written consent.



607 PLANT COMPONENTS

STORAGE VACUUM SYSTEMS COMPRESSED GASES x ا 316"X 4" LG MACHINE SCREW -STD. I 2" X 4" LG. IRON PIPE "RUBBER BALL - 12" REDUCER BUSH TO 2" BILL OF MATERIALS 2 - 4" x 16" STRIPS 4 - 316" x 4" LG. MACHINE SCREW 1 - PIPE 12" \$ X 4" LG. -STD. 12" X 2"LG. IRON PIPE 1 - PIPE 2" 4 X 2" LG. 1 - REDUCER 12" 4 TO 2"4 I - I" RUBBER BALL VACUUM RELIEF VALVE Figure 607.2.2.5-4 Approved: Safety Director Originated By: Air Products

W. W. Schmoyer

W. L. Ball

January, 1964

OXYGEN SERVICE

1. PURPOSE

This standard lists classifications of cleaning required for equipment in air separation plants and oxygen service. The various methods used in establishing acceptance of materials for oxygen service is discussed. This standard is issued to inform personnel of the existing methods of inspecting material for acceptability for oxygen service and establish acceptance criteria. It is not the intent of this standard to determine when material shall be inspected, but to provide information such that the responsible personnel can evaluate the necessity for inspection and the means to accomplish this inspection.

2. SCOPE

This standard shall be used at all Air Products and Chemicals, Inc. and affiliates producing and distribution locations, equipment fabricating facilities, and air separation plant construction sites in determining the acceptability of material for oxygen service where specific inspection procedures and acceptance criteria (such as QCL's) are not applicable.

3. DETERMINATION OF ACCEPTABLE CLEANING

The information following shall be utilized to establish classifications of cleaning required based on the intended service and determine the cleanliness requirements of equipment, piping, and valves. Equipment for a pure product fluid other than oxygen (such as nitrogen) that may be converted to oxygen service shall be cleaned to the applicable classification for oxygen service.

(A listing of air separation plant components and the required cleaning classification may be found in QCL 101F. QCL's 114 through 117 list detailed information on the classifications of cleaning which are discussed on the following pages.)

- A. Any surface which will contact, through normal use, a pure or enriched oxygen atmosphere shall be free of all loose (or potentially loose) slag, scale, metallic chips, or any other foreign materials as shown in the following subsections.
 - (1) Class AAA Cleaning Class AAA is the most stringent standard cleaning classification. It is applied to equipment with moving parts such as reciprocating compressors, expanders, pumps, valves, etc. which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AAA cleaning is as follows:

OXYGEN SERVICE

3. DETERMINATION OF ACCEPTABLE CLEANING (Cont'd)

A., (1) Continued

a. Bright White Light Inspection

Surfaces inspected shall be free of all moisture, residue, discoloration (other than that which is due to the metal), particles having a diameter larger than 500 microns and fibers exceeding 2000 microns in length. The surface shall also be free of any excessive concentration of smaller particles or fibers detectable with the naked eye.

b. Wipe Test

Surfaces shall be wiped with clean white filter paper and the filter paper inspected to insure the absence of oils not detectable by black light, residue, discoloration other than that which is due to the metal, particles, and fibers as covered in Item a.

c. Black Light Inspection

Surfaces inspected shall be free of any fluorescence other than isolated spots of lint and dust detectable by black light.

- (2) Class AA Cleaning Class AA is the more commonly used standard cleaning classification which is applied to stationary parts which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AA Cleaning is as in Class AAA with the exception of the maximum diameter particle size permitted which is increased to 1000 microns.
- (3) Class A Cleaning Class A is the most relaxed standard cleaning classification applied to equipment which can contact a liquid air or an oxygen enriched atmosphere. Acceptance criteria for Class A cleaning is as follows:
 - a. Bright White Light Inspection

Surfaces inspected shall be free of visible hydrocarbons, all particles having a diameter greater than 1500 microns and fibers having a length greater than 6000 microns.

OXYGEN SERVICE

3. <u>DETERMINATION OF ACCEPTABLE CLEANING</u> (Cont'd)

A., (3) Continued

b. Wipe Test

Surfaces shall be wiped with clean white filter paper and the filter paper inspected to insure the absence of residue and oils not detectable by black light.

c. Black Light Inspection

Surfaces inspected shall be essentially free of fluorescence. Isolated particles of fluorescent lint and a very low intensity fluorescence will be acceptable.

- B. The standard cleaning classification which is applied to equipment which will not contact an oxygen enriched atmosphere is Class B. Acceptance criteria for Class B cleaning is as follows:
 - (1) Surfaces shall be free of all accumulations of loose metallic chips, scale, slag, or other foreign particles.
 - (2) Surfaces inspected shall be free of excessive grease, oil, or other hydrocarbons.

4. METHODS OF INSPECTION

The various methods utilized in determining acceptability of surfaces exposed to oxygen service and specified above are discussed below with the limitations.

A. Inspection of Particulate Matter

Accessible surfaces shall be inspected for particulate matter using adequate lighting with the naked eye, the aid of a pocket magnifying glass (preferably calibrated) or other means. The limit of detection of the average naked eye (20/20 vision) is approximately 40 microns. 100 microns equal .004 inch; 500 microns is the approximate diameter of the shaft of a straight pin; 1000 microns is approximately the diameter of a common paper clip.

608 CLEANING AND INSPECTION

MATERIALS OXYGEN SERVICE

4. METHODS OF INSPECTION (Cont'd)

B. Black Light Inspection

Accessible surfaces shall be inspected for hydrocarbons which fluoresce with a long wave black light of approximately 3600 Angstroms. (See Table 1 for a partial listing of hydrocarbon lubricants and coolants that fluoresce). It is important to recognize that many hydrocarbons do not fluoresce and that others might fluoresce only because a fluorescent material has been added by the manufacturer. The removal of this fluorescent additive, such as might occur at elevated temperatures experienced in a compressor, could result in loss of fluorescence. Conversely, all materials that fluoresce are not hydrocarbons, such as certain solder fluxes and Oakite residues.

Surfaces inacessible to inspection with the eye or a boroescope may be inspected by comparing new unused solvent and the effluent solvent rinse under a black light and bright white light. Any increase in discoloration in the solvent rinse shall be cause for rejection. It must be recognized that this method is the least positive method and may be used as a last resort being fully aware of its limitations. It is preferable to obtain a sample of the rinse and have an analysis performed to detect hydrocarbons (See Section E).

C. Bright White Light

Accessible surfaces shall be visually inspected with a bright white light for discoloration which could be an indication of hydrocarbons which do not fluoresce. Discoloration which is determined to be an integral part of the metal is acceptable. The bright white light may also be used as an aid in the particulate matter inspection and the wipe test.

D. Wipe Test

Accessible surfaces shall be wiped with clean white filter paper on two representative areas for an indication of hydrocarbons. Discoloration other than from oxidation of the metal and fluorescence is not permitted on any portion of the filter paper that was in contact with the surface being inspected.

OXYGEN SERVICE

4. METHODS OF INSPECTION (Cont'd)

E. Solvent Rinse Analysis

The most positive inspection procedure for the determination of material being free of hydrocarbons is an analysis of the solvent rinse although this method is impractical for the majority of applications. This should be accomplished by obtaining a representative sample in a metal container which has been thoroughly washed in solvent and is free of any hydrocarbon seals (rubber, paraffin impregnated seals, etc.) in the lid. The quantity of solvent introduced and recovered should accompany the sample with a solvent "blank" (clean, unused solvent) to R & D for analysis.

NOTE: Additional information is available in the Analytical Testing Standards Manual, Section 675.12.01, Analytical Test.

OXYGEN SERVICE

TABLE I

The following lubricants, coolants, and solvents are listed as a guide in categories according to the fluorescing properties.

DESCRIPTION	PROPERTIES
Compressor Lubricants & Reciprocating Expanders (as manufactured)	
Mobil Kote 501 Mobil DTE 105 Mobil DTE 103 Mobil Heavy Mobil Medium Heavy Mobil Light	Bright Bright Bright Bright Bright Bright
Havoline #40	Bright
Havoline #30	Bright
Solnus 500	Bright
Solnus 300	Bright
Ucon 50 HB 55	Bright
Ucon 50 HB 280	Bright
Ucon 50 HB 170	Medium
Ucon 50 HB 660	Medium
Cellulube 220	Medium
Cellulube 300	Medium
Cellulube 550	Medium
Oxygen Compatible Lubricants	
Florolube Halocarbon Kel-F Refrigeration System Lubricant	Very Slight Very Slight Very Slight
Capella	Bright
Sunisco 3G	Bright

OXYGEN SERVICE

TABLE I (Cont'd)

DESCRIPTION

PROPERTIES

Turbo Expander Lubricant

Gulf Paramount 39 Texaco Paramount Bright Bright

Coolants

Cuprol B-6

Medium

Solvents

Paco Methylene Chloride Trichloroethylene Medium Very Slight Very Slight

<u>Others</u>

RP-1 (rocket propellant)
Nujol (mineral oil)
Saturated straight chain
hydrocarbons (hexane, etc.)

None None None

OXYGEN

COMPATIBLE MATERIALS

PURPOSE

This standard lists materials which are approved by the Safety Department for use in oxygen service.

2. SCOPE

Applicable to all oxygen-generating, -charging, -manufacturing, -storage, and oxygen-distribution facilities.

3. GENERAL

Many materials have been examined to determine their compatibility with The approved materials have been classified, according to use, and alphabetically listed below. The oxygen-compatible material list will be expanded and revised to keep it up to date and comply with current practice. The Safety Department does not have a program to develop new sources of suppliers of oxygen-compatible material. This function is the responsibility of all groups concerned with the specification and use of this class of material. The services of Research and Devlopment shall be called upon to verify the oxygen-compatibility of questionable material. The Safety Department should be consulted in setting up suitable test programs and in interpretation of test data.

Any deviation to the approved and published list must have the written consent of the Safety Department. Requests, made to the Safety Department for the purpose of including acceptable material on the approved list, shall be made only when it is advantageous to add this material to the existing list of oxygen-compatible materials. All such requests shall be accompanied by a Research and Development analysis report on subject material.

When a supplier's name is given with the material, it indicates that only this material and source of supply is acceptable. The absence of a supplier's name indicates the material is available from a number of sources provided the specifications for the material are satisfied.

CLEANING AGENTS

A. Chlorinated Sclvents

Used in closed process systems, vapor degreasing equipment, and piece cleaning. Solvent must be inhibited grade for metal cleaning of equipment in oxygen service and have a maximum weight residue of 0.001 per cent upon evaporation.

Air Products

Originated By:

W. W. Schmoyer

Approved: Safety Director

W. L. Ball

669 COMPATIBILITY OF MATERIALS

OXYGEN

COMPATIBLE MATERIALS

- 4. CLEANING AGENTS (Cont'd)
 - A. Chlorinated Solvents (Cont'd)
 - (1) Methylene Chloride

Suppliers - Diamond Alkali Co.

E. I. Du Pont de Nemours & Co.

Dow Chemical Co.

(2) Trichloroethylene

Suppliers - Diamond Alkali Co.
E. I. Du Pont de Nemours & Co.

Dow Chemical Co.

(3) Methyl Chloroform (1, 1, 1 Trichloroethane)

Suppliers - Dow Chemical Co.
The C. P. Chemical Solvents, Inc. - Newark, N.J.
Tect, Inc. - Dumont, N.J.

NOTE

The above solvents are not compatible in oxygen service. Make certain that all solvent is completely vaporized from parts and equipment before they are returned to oxygen service.

B. Oakite Solutions

Used in tank cleaning of parts and equipment. Refer to Quality Control Standard QCL 103F.

- C. Other
 - (1) Electric Motor Cleaning Solvent SS-25.

Supplier - National Disinfectant Co. - Dallas, Texas

Air Products

Originated By:

Approved: Safety Director

Date

W. W. Schmoyer

W. L. Ball

OXYGEN

COMPATIBLE MATERIALS

5. COATING, PIPING

- A. Underground
 - (1) Plasite, No. 7122H, cold set coating

Supplier - Wisconsin Protective Coating Co. - Green Bay, Wisconsin

(2) Tarset

Tarset's use is restricted to carbon steel portions of underground piping. Stainless steel fire breaks in underground lines will be coated with Plasite, Item (1) above.

Supplier - Pittsburgh Chemical Co. - Pittsburgh 19, Pennsylvania

- B. Exposed
 - (1) Aluminum paints
 - (2) Iron chromate primers
 - (3) Zinc chromate primers

6. CONSTRUCTION MATERIALS

- A. Concrete Resurfacing
 - (1) Thoro Patch

Good for normal traffic use. Product does not hold up too well for cylinder traffic.

Supplier - Standard Dry Wall Products, Inc. - New Eagle, Pennsylvania

7. GASKETS

A. Garlock #900, 1/16" thick compressed asbestos. Install gaskets dry.

Supplier - Gardock Manufacturing Company - Palmyra, New York.

Specification Reference - Technical Bulletin No. 26, Page 3
Paragraph 2, Gasketing.

DES 579.2.3 Gaskets

Air Products

Originated By:

Approved: Safety Director

Date

W W Schmoyer

W. L. Ball

609 COMPATIBILITY OF MATERIALS

OXYGEN

COMPATIBLE MATERIALS

7. GASKETS (Cont'd)

B. Durabla

Supplier - Durabla Manufacturing Company, New York City, N. Y.

C. Permatex #1516

Used for flat or flanged joints not subject to motion or impact.

Supplier - Permatex Company, Brooklyn, New York.

8. INSULATION

A. Cold Boxes

(1) Perlite

Grade A - Compacted density, 7 to 10 lbs./cu. ft.

Grade B - Compacted density, 4 to 6 lbs./cu. ft.

Maximum Water Content - 0.5 per cent.

Specification - Design Engineering Standard 581.1

(2) Mineral Wool

Granulated, free of impurities

Maximum Oil Content - 3.5 lbs./ton of material. Oil must be distributed evenly throughout.

Specification - Design Engineering Standard 581.2

(3) Glass Wool

Fibre Glass - Basic Fibre No. 28, Type E. Glass

Maximum Oil Content - 3.5 lbs./ton of material. Oil must be distributed evenly throughout.

Maximum Water Content - 0.5 per cent.

Compacted Density - 6 lbs./cu. ft.

Specification - Design Engineering Standard 581.3

Supplier - Owens-Corning Fibre Glass Division, Ashton, Rhode Island

Air Products

Originated By:

Approved: Safety Director

Date

W. W. Schmoyer

W. L. Ball

OXYCEN

COMPATIBLE MATERIALS

8. INSULATION (Cont'd)

- B. Vessels and Piping for oxygen and other cryogenic service at temperatures below the liquefaction temperature of air.
 - (1) Foamglas Insulation

Supplier - Pittsburgh-Corning Corp., Pittsburgh, Pa.

Used with:

- a. Keene Binder, as binder or adhesive material
 Supplier Pittsburgh-Corning Corp., Pittsburgh, Pa.
- b. Sealfas Mastic, 31-97, as the protective coating.Supplier Benjamin Foster Co., Phila., Pa.
- c. Aluminum outer casing banded with aluminum bands, as the protective coating.

On insulated transmission lines which require the use of expansion joints, joint spacing at intervals of ten (10) feet should be made of fibre glass as specified in 8,A (3) above. The protective coating should be Sealfas Mastic 31-97. Reference Construction Specification 270.

- C. Vessel Supports applies to supports needed for shipping only, and not structural supports.
 - (1) Transite

Supplier - Johns-Manville

9. LUBRICANTS

- A. Fluorocarbon Lubricants
 - (1) Kel-F No. 1 Light oil *
 Kel-F No. 10 Heavy oil *
 Kel-F No. 90 Medium Grease *

Supplier - Minnesota Mining and Mfg. Co., St. Paul 6, Minn.

* Not to be used with aluminum or magnesium.

609 COMPATIBILITY OF MATERIALS

OXYGEN

COMPATIBLE MATERIALS

- 9. LUBRICANTS (Cont'd)
 - A. Fluorocarbon Lubricants (Cont'd)
 - (2) Halocarbon 4-11 Light oil *
 Halocarbon 11-14 Light oil *
 Halocarbon 25-10M Grease *

Supplier - Halocarbon Products Corp., Hackensack, N. J.

(3) Fluorolube FS-5 - Light Oil *
Fluorolube T-80 - Heavy Oil *
Fluorolube GR362 - Light Grease *

Supplier - Hooker Chemical Corp., Niagara Falls, New York

- B. Molybdenum Disulfide Lubricants
 - (1) Molybdenum Disulfide

 Supplier Air Products and Chemicals, Inc., Allentown, Pa.
 - (2) Molylube "N"

 Supplier Bel-Ray Company, Farmingdale, New Jersey
 - (3) Moly "99"

 Supplier Moly Lubrication Products, Glen Cove, N. Y.
- C. Synthetic Lubricants

Use of these lubricants is restricted to vacuum pump service only, and is not intended for direct contact with oxygen.

- (1) Tricresylphosphate (TCP)
- (2) Cellulube 220
 Supplier Celanese Corp. of America, New York, N. Y.
- * Not to be used with aluminum or magnesium.

Page 7

OXYGEN

COMPATIBLE MATERIALS

10. SEALANT, COLD BOX PANEL

A. Putti-Rope

Supplier - National Greenhouse Co., Pana, Illinois

NOTE

An effective panel seal must be established by using a minimum amount of sealant.

B. Synthetic Rubber Gasket

11. SEALANT, PIPING

- A. Permacel 412 Ribbon Dope (Tape Teflon, Thread Sealant) **

 Supplier Permacel Corp., New Brunswick, New Jersey
- B. Thread Tape **
 Supplier John Crane Co.
- C. Pipe Thread Sealant No. 48 and 537 **
 Supplier Minnesota Mining and Mfg. Co., St. Paul, Minnesota

12. SOLUTIONS, LEAK TEST

Leak test solutions are classified into two groups. Group 1 solutions are special formulated solutions developed for use aroung oxygen and which are not usually sensitive to impact energies. Group 2 solutions are concentrated soap or detergent solutions and are generally sensitive to impact energies. The residue upon evaporation of solutions in both groups are flammable and therefore become a hazard when used to test oxygen systems for leaks. Since solutions of both groups are water soluble, the hazard can be eliminated by adequately water rinsing the residue from all surfaces on which leak test solutions have been applied.

** Limited to use up to 400°F due to decomposition at high temperatures.

609 COMPATIBILITY OF MATERIALS

OXYGEN

COMPATIBLE MATERIALS

12. SOLUTIONS, LEAK TEST (Cont'd)

- A. Group 1 Special formulated solutions.
 - (1) Sherlock Leak Detector, Type CG

Supplier - Winton Products Co., Inc., Charlotte, N. C.

(2) Snoop Leak Detector

Supplier - Nuclear Products Co., 15635 Saranac Road, Cleveland 10, Ohio

(3) Oxequip 17-A Oxy-Leak

Supplier - Oxygen Equipment & Service Co., 8335 S. Halsted St., Chicago 20, Illinois

(4) F-33 Detergent

Supplier - Dow Chemical Co.

(5) Leak-Tec

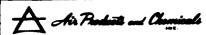
Supplier - American Gas & Chemicals, Inc., New York, N. Y.

B. Group 2 - Concentrated Soap and Detergent Solutions

This group includes Joy, Tide, Ivory, Fels Naptha and other soaps and liquids which are available through normal retail stores.

CAUTION

The residue of both group solutions is flammable. All surfaces to which leak test solutions have been applied must be adequately rinsed with water to remove the residue.



AIR SEPARATION PLANT

SITE

1. PURPOSE

This standard check list is designed to assist in the evaluation of the suitability of a proposed site for an air separation plant. A complete discussion of the principles outlined in this check list will be found in Section 605.1 Plant Site Criteria, Air Separation.

2. SCOPE

This check list applies to the selection of a site for air separation plant.

3. ATMOSPHERIC CONTAMINATION

- A. Make a chart (Use 900 ft. radius Chart, 610.1.1.1) of the proposed site and surroundings within 900 feet. Indicate:
 - (1) All flares, stacks, vents, and disposal areas, showing composition and quantity of contaminants from each and elevation of each.
 - (2) Prevailing winds -- by windrose.
 - (3) Location of sources and the composition of possible process leaks that would be hazardous to the air plant.
 - (4) Future plants and noting any features that would be of concern to the air plant.
- B. Make a chart (use 5600 ft. radius chart, 610.1.1.2) of area within one mile of site showing same data as in (A) above. It is not necessary to repeat information included on 900 ft. radius chart, 610.1.1.1.

C.	After studying the data obtained above, is there
	any indication that there will be a contaminant
	problem at the air intake?

D.	Will it be necessary, or advantageous to move
	or relocate any stacks or vents, or other sources
	of contemination?

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NO

YES

Ais Products

Originated By:

W. L. BALL

Approved Salety Director

F. HIMMELBERGER

11-28-60

610 CHECK LIST

AIR SE	PARATION PLANT	SITE		
	· •	YES	NO	
4. <u>SA</u>	MPLING .			
Α.	After study of the data obtained above, will air sampling and analysis be required?			
В.	Will it be difficult to time sampling to catch peaks of atmospheric contamination?			
5. <u>EX</u>	POSURE TO HAZARDS FROM OTHER EQUIPMENT			
Α.	Will the air plant be exposed to damage or involvement in the event of fire or explosion in adjacent plants or equipment?			
В.	Will the air plant be adversely affected (Other than the process air) by the operation of, or discharges from, adjacent equipment? (i.e., corrosive or toxic gases or fumes, noise, etc.)	•		
6. <u>e</u> f	FECT OF THE PLANT ON SURROUNDINGS			
Α.	A. Will adjacent equipment or operations be adversely affected by:			
	(1) Noise of compressors, turbo expanders, or vents?			
	(2) Vented gaseous oxygen?			
	(3) Spills of cryogenic liquids?			
	(4) Vents or blowdowns that may contain quantities of oil or oily mists?			
В.		:		
c.				
	(2) Noise?			
	(3) Traffic to or from the plant site?			
*********	Originated By: Approved Balaty Director			

AIR	SEP	SEPARATION PLANT			SITE	
					YES	NO
7.	CLI	MATE ANI	TERRAIN			
	Α.	A. Will the proposed plant be susceptible to damage, work stoppage, or excessive maintenance from any of the following?				
		(1) E	arthquake?			
		(2) H	urricane or tornado?		į	
		(3) F	looding?			
		(4) Po	oor Drainage?			*Producesson
			ither excessively high emperatures?	or low atmospheric		
		88	ther climatic or local alt in the atmosphere, maracteristics, etc.?	•		
8.	FIR	E AND PO	DLICE PROTECTION			1
	Α.	In the event of an emergency, will it take more than five minutes to receive assistance from:				:
		(1) Fi	re department?			;; ;
		(2) Po	lice department?			:
			espital, plant doctor, dical service?	or other qualified		
	В.	Is there any question as to the quality of equipment or personnel of either the Police or Fire Departments?				
	c.	volume system 50 psig	problem be encountered or pressure in the fir will have 150 psig or residual pressure at 500 gpm total per hyd			
	D.	. Will a supplemental water supply (Standpipe or ponds) be required?				and the second s
	E.		e any record of season g critical?	al water shortages		i de la companya de l
			Originated By:	Approved: Safety Director	<u> </u>	
Air	Ros	wot	W. L. BALL	F. HIMMELBERGER	Dete 11	-28-60

AIR	SEF	PARATI	ON PLANT		SITI	3
					YES	NO
8.	FIR	E AND	POLICE PROTECTION (Conto	1)		
	F.		the plant be operated war 2 men) during the night			
9.	ACC	ESS R	OADS AND COMMUNICATIONS			
	Α.		emergency equipment have oaching or leaving the s	•		
		(1)	Traffic congestion or in the primary road?	nterruption on		
		(2)	Dear-end roads on the s	ite?		
•		(3)	Lack of alternate entra	nces or exits?		
	в.	W111	an emergency be intensi:	fied because of:		
		(1)	Lack of communication for switchboard or telephone			
		(2)	Lack of watchman service manual fire alarm system	•		
10.	SPA	CE				
	Α.		safety and operational pruse of lack of space for			
		(1)	Storage of spare parts a supplies?	and operational		
		(2)	Proper housekeeping?			
		(3)	Daily operational activ	ities?		
		(4)	Maintenance work (included and repair of exchangers	-		
		(5)	Storage and transfer of and gas?	product liquid		
		(6)	Traffic movement within	the plant site?		
		(7)	Future expansion?			
da -	D .	Lizh	Originated By:	Approved: Safety Director	0.00	

AIR	IR SEPARATION PLANT		SITE		
			YES	NO	
11.	SUM	MARY			
	ind	'YES" answer to any of the above questions dicates a condition detrimental to the safe eration of the proposed plant.			
	det	swer the following questions by considering each crimental condition by itself and in relation the overall condition for a suitable plant site.			
	Α.	Must the process cycle be modified to accommodate the plant to the site? (If answered "YES", state the desired change).			
	n	Are there any undesirable features of the site			
		or its surroundings that must be rectified to make it suitable for an air separation plant? (If answered "YES", state the desired changes).			
	с.	Is the site suitable for an air separation plant? (If answered "NO", state the reasons if not done so in the above questions).			
		SUBMITTED BY			
Air i	B	Originaled By: Approved: Safety Director	Dele		
18	0000	W. L. BALL F. HIMMELBERGER	11-28	8-60	

EMERGENCY PROCEDURES

1. PURPOSE

This standard establishes the procedures necessary to implement a program to cope with energency conditions that may arise due to equipment malfunction or failure, human failure, extreme climatic conditions, or national emergency.

2. SCOPE

This standard covers all APCI facilities to the extent of applicability determined by the function and personnel utilization of the facility.

3. APPLICABILITY

Applicability of this standard by a facility is determined by two factors—the function of the facility, and the number of personnel required to perform the function. The table which follows relates the two factors and guides the manager in determining the procedures applicable to his facility.

A. Function

The function of a facility is determined by the nature of its activity which can be broken down into five groups.

- (1) Office includes business, engineering, and sales offices and juvolves no other function.
- (2) Manufacturing shops engaged in processing raw materials into finished products.
- (3) Production operation of equipment to produce cryogenic liquids or gases. Generally includes storage and distribution functions.
- (4) Storage facilities storing cryogenic liquids or gases and other warehouse products.
- (5) Distribution facilities for distribution of cryogenic liquids, and for conversion of cryogenic liquids to gaseous products for pipe line or cylinder use by transportation media.

626 SAFETY CONTROL PROCEDURES

EMERGENCY PROCEDURES

3. APPLICABILITY (Cont'd)

B. Personnel

The number of personnel utilized on each working shift is divided into three groups:

- (1) 1 to 3 people
- (2) 4 to 10 people
- (3) 10 or more prople
- C. Table of Applicability

MANPOWER PER SHIFT	OFFICES	MANUFACTURING	PRODUCTION	STORAGE	DISTRIBUTION
1-3 people	DE	ADE	ADE	ADE	ADE
4-10 people	CDE	ACDE	ACDE	ACDE	ACDE
10 or more	CDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF

Code: A - Equipment shut down procedures

- B Fire fighting crews
- C First aid crews
- D Emergency phone numbers
- E Building evacuation plans and charts
- F Emergency rosters

4. RESPONSIBILITY

A. The person responsible for each APCI facility, or his duly appointed representative (s), is responsible for developing and implementing emergency procedures covering the following:

EMERGENCY PROCEDURES

4. RESPONSIBILITY (Cont'd)

A. Continued

- (1) Shutdown procedures
- (2) Crews for fire fighting and first aid
- (3) Building evacuation
- (4) Emergency rosters
- (5) Public relations
- (6) Periodic tests of emergency procedures
- B. The Corporate Safety Department is available to assist the Managers of each APCI facility in the development of emergency procedures for his area and their application.

5. DEFINITIONS

- A. Facility pertains to an individual location.
- B. Manager pertains to the supervisor of a facility.
- C. Appointed representative pertains to other personnel delegated by the manager with the assignment of safeguarding personnel and equipment.
- D. Equipment malfunction or failure pertains to mis-operation, improper design, and change in environment which could give rise to emergency conditions.
- E. Human failure pertains to lack of training, or physical or emotional reactions which could give rise to emergency conditions.
- F. Climatic conditions pertain to severe storms, hurricanes, earthquakes, tornados, flood, cold, and heat which could cause emergency consitions.
- G. National emergency pertains to war, acts of war, or area conditions which could cause emergency situations.
- H. Equipment pertains to the necessary items required to manufacture, process, distribute, and use any material or product in the conduct of APCI business.

626 SAFETY CONTROL PROCEDURES

EMERGENCY PROCEDURES

5. EMERGENCY EQUIPMENT SHUTDOWN PROCEDURES

The Manager, or his duly appointed representative (s), of each APCI facility and office will prepare procedures for equipment shutdown in the event of emergency due to equipment malfunction or failure, human failure, severe climatic conditions and national emergency.

Procedures will be developed covering emergencies. Consideration will be given to:

- A. Stopping all equipment
- B. Removing mobile distribution equipment
- C. Discontinuing service facilities
- D. Protecting APCI vital documents
- E. Assigning and training personnel and alternates to perform specific duties
- F. Reviewing procedures as required due to changes in equipment and function
- G. Distributing procedures and personnel rosters as follows:
 - (1) At the direction of the Department Manager
 - (2) To the Corporate Safety Department

7. EMERGENCY CREWS FOR FIRE FIGHTING AND FIRST AID

The Manager, or his duly appointed representative (s), of each APCI facility and office will establish emergency crews for fire fighting and first aid to combat fires prior to the arrival of civil fire fighters and to render first aid prior to the arrival of medical help.

- A. Fire Fighting
 - (1) Appoint a fire marshall
 - (2) Train emergency fire fighting crews through the cooperation of the local fire departments
 - (3) Identify the fire fighting facilities in his area

EMERGENCY PROCEDURES

7. EMERGENCY CREWS FOR FIRE FIGHTING AND FIRST AIR (Cont'd)

- A. Fire Fighting (Cont'd)
 - (4) Review fire fighting program in his area every six months or as required by equipment and function changes.
 - (5) Prepare a roster of personnel trained in emergency fire fighting procedures and distribute to:
 - a. Bulletin boards in his area
 - b. As directed by the Department Manager
 - c. Corporate Safety Department

B. First Aid

- (1) Arrange for first aid training of emergency crews, utilizing the American Red Cross or other civic groups who have established first aid programs.
- (2) Prepare a roster of emergency first aid personnel and distribute to:
 - a. Bulletin boards in his area
 - b. As directed by the Department Manager
 - c. Corporate Safety Department
- C. Emergency Telephone Numbers

Post on all bulletin boards and convenient locations in all work areas, the telephone numbers to use in the event of an emergency.

8. BUILDING EVACUATION

The Manager, or his duly appointed representative (s), of each APCI facility will prepare a plan for quickly evacuating all building in an orderly fashion and in a minimum of time. He will:

- A. Publish the plan showing evacuation routes for each area of his responsibility.
- B. Clearly identify all evacuation routes and exits.
- C. Appoint and train personnel to direct an orderly evacuation and secure his area before leaving.

EMERGENCY PROCEDURES

8. BUILDING EVACUATION (Cont'd)

- D. Maintain a roster of all personnel normally working in his area of jurisdiction.
- E. Maintain a separate roster of personnel specially trained for evacuation work.
- F. Review and revise the evacuation plan every six months or sooner if conditions prevail which warrant changing the plan.
- G. Distribute the plan and rosters as follows:
 - (1) On the bulletin boards in his area
 - (2) At convenient locations in all work areas.

9. EMERGENCY ROSTERS

A. The Manager, or his duly appointed representative (s), of each APCI facility or office will, in addition to other roster requirements listed in this standard, continue to train personnel in his area to act as alternates for emergency assigned duties. Personnel not assigned duties on emergency status, but who have specific talents or trades, will be listed on a separate emergency roster.

Copies of the alternates for emergency duty and a separate emergency roster will be distributed to:

- (1) Bulletin boards in the area
- (2) Corporate Safety Department

10. TESTING EMERGENCY PROCEDURES

Test emergency procedures at regular intervals.

- A. Emergency equipment shutdown procedures can be substituted for normally scheduled shutdowns which are coordinated with production schedules. The frequency of testing procedures is at the direction of the Manager.
- B. The emergency fire fighting crews and their equipment will be tested every six months. Retraining shall be accomplished annually.
- C. First aid crews shall demonstrate their proficiency every six months. Retraining shall be accomplished annually.
- D. Building evacuation shall be tested annually.

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EMERGENCY PROCEDURES

11. PUBLIC RELATIONS

The Manager, or his duly appointed representative (s), at a facility location is the only person authorized to make public statements concerning an emergency condition which might exist. Statements made should be:

- A. Confined to the extend of damage, but not the cause, the monetary value, or the process involved until cleared by the investigation and legal groups.
- B. Confined to the numbers of personnel involved, but not to release names of injured until families have been notified.

12. FORMS

The forms associated with this standard are printed on 8 1/2" x 11" paper stock. Each form has a 1/8" border and major headings printed in red for identification with the emergency program.

- A. Emergency Telephone Numbers, Form No. 2035
 - (1) This form contains the phone numbers of emergency service groups, and the supervisor people responsible for the facility. Dialing instructions applicable to a facility must also appear on this form.
 - (2) Display the form on all bulletin boards, and at convenient locations in all work areas.
- B. Building Evacuation, Form No. 2036
 - (1) This form contains the plan of the facility, building, or area showing the location of all exits, fire extinguishers, fire alarms, and first aid services.
 - (2) Display the form on all bulletin boards and at convenient locations in all work areas.
- C. Emergency Personnel, Form No. 2037
 - (1) This form contains the names of personnel trained in first aid, fire fighting, and other emergency activities.
 - (2) Display the form on all bulletin boards and at convenient locations in all work areas.

626 SAFETY CONTROL PROCEDURES

EMERGENCY PROCEDURES

12. FORMS (Cont'd)

- D. Personnel Roster, Form No. 2038
 - (1) This form contains the names, addresses, and phone numbers of all employees working at each facility.
 - (2) The use of this form is at the discretion of the manager. It may be useful at locations having a small number of personnel employed. Locations employing large numbers of people may find Kardex, IBM, or other systems more convenient for their use. This form was designed for future use when APCI Emergency Plans are integrated with Civil Defense Plans.

13. GENERAL

Emergencies confined to facilities owned and operated by APCI will be handled according to procedures listed in this standard.

Facilities owned by others and operated by APCI which are part of large complexes will comply with procedures established by that organization after securing your own area.

In national emergency, comply with procedures established by Civil Defense or appropriate agency after securing your own area.

629 SOLVENT AND CLEANERS

Page 1

GENERAL

DEVIATIONS

CLEANING FOR OXYGEN SERVICE

1. PURPOSE

This standard provides the policy to be followed when requests for deviations to the Quality Control Standards are requested by API, our vendors and contractors for cleaning our equipment for 'Oxygen Service".

2. SCOPE

This standard applies to all API equipment that is indicated by our drawings, subcontract agreements and vendors for "Oxygen Service" and described by a Quality Control Standard.

3. GENERAL

All API equipment requiring cleaning for "Oxygen Service" shall be cleaned according to the applicable Quality Control Standard listed in Section "F" of the Quality Control Layout manual.

If another method or substitute cleaning fluids be proposed other than that covered in the applicable Quality Control Standards, they shall be subjected to analysis and study by the Safety Department for approval or rejection. Until final approval of the deviation, the existing Quality Control Standards on cleaning procedures shall be enforced.

Air Products

Originated By:

H. SMITH

Approved: Safety Director

Date

6-19

L. BALL

6-19-61

Page 1

DELUGE SYSTEM

LOX LOADING FACILITY

1. PURPOSE

This standard establishes a fire protection system for liquid oxygen loading facilities.

2. SCOPE

This standard applies to all liquid oxygen loading facilities designed by APCI following the date of issue of this standard. Liquid oxygen loading facility shall be interpreted as being a facility where daily transfer operations are conducted on a routine basis. Large tonnage plants where additional capacity is not provided shall be reviewed with the Safety Department to determine if the infrequent large quantities of LOX transferred during plant shutdown necessitate a deluge system. (In determining if a deluge system is required, consideration shall be given to the facility capacity, if it is a multiplant facility, and the location of other fire extinguishing equipment.) All liquid oxygen loading facilities shall be provided with a deluge system as described in this standard. Exceptions to this standard require the approval of the Safety Department.

3. EQUIPMENT

- A. The supply header shall be provided with a block valve with valve stem extension that is remotely located a minimum distance of 30 feet from the nearest trailer slot.
- B. The deluge system shall be composed of one or two nozzles per trailer slot. The spray nozzles shall have a minimum effective reach of 30 to 40 feet capable of discharging a minimum of 80 gpm fog spray per trailer slot. The nozzles shall be located such that they will be an approximate minimum of 10 to 15 feet from the rear surface of the trailer.
- C. A drain valve shall be provided at the dead-ended section of the deluge header to permit periodic flushing of the header. The deluge header should be sloped toward the drain valve to facilitate draining of the system. Consideration should be given to a connection for an air purge to insure complete water removal from the header after actuation of the system if the design is such that water can collect in a low spot.
- D. The wheel stop shall be so designed that the stop is open at the bottom to permit nozzles to flush the concrete apron in a direction from the rear of the trailer toward the front.

Air Products

Originated By:

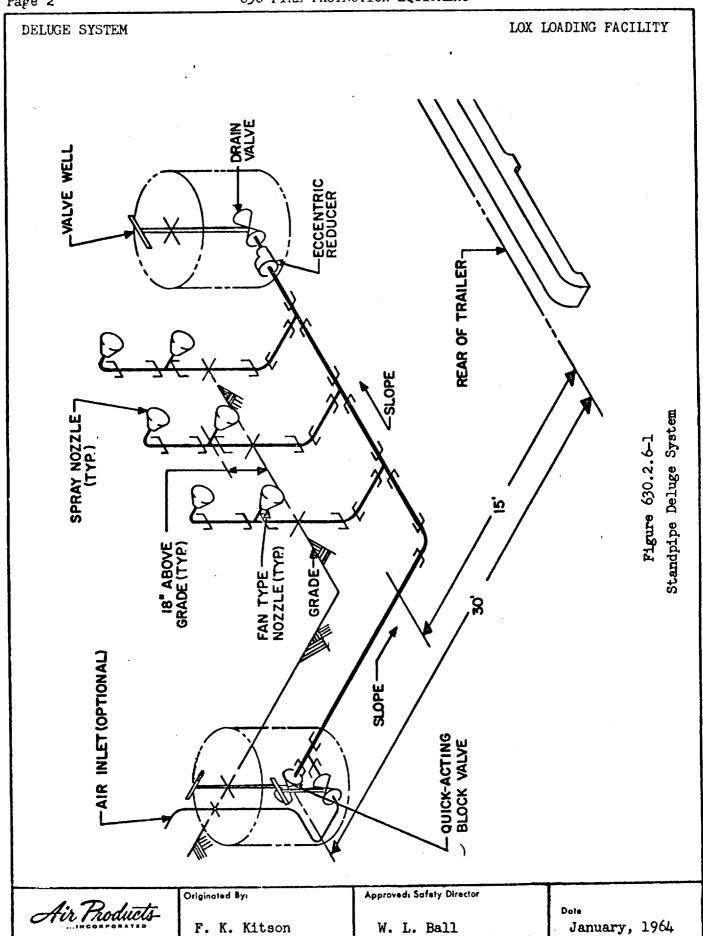
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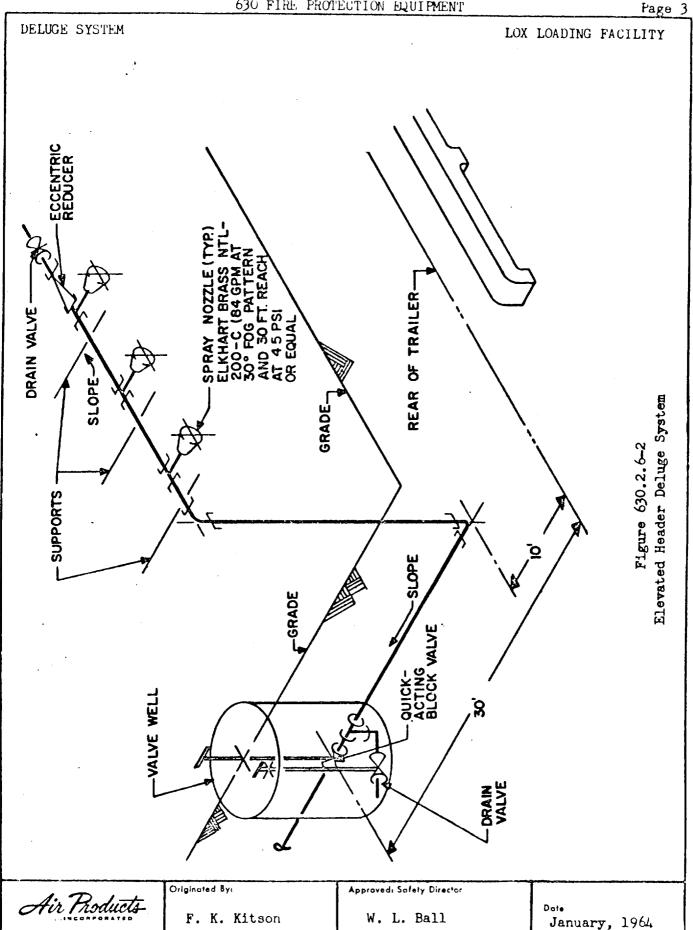
Approved: Safety Director

Date

W. L. Ball

January, 1964







March 26, 1965 Number 49

Caution! Sniff Testing Cylinders Has Its Hazards

Safety-Gram No. 31 "Sniff Those Cylinders Before Refilling" recalled some incidents where explosive mixtures were actually found in cylinders being returned to our facilities for refilling.

Nitrogen is being used in increasing amounts as an inert atmosphere for chemical processes under the control and operation of other organizations. Because of misoperation or the lack of other adequate design safety considerations in the process equipment being used the possibility exists that some of the products of the process may backflow into the nitrogen cylinders. When this occurs, personnel at our filling plants are exposed to an unexpected hazard when performing a sniff test. Some incidents which have been reported in the last several months point out this additional hazard.

- 1. A strange odor detected in 15 nitrogen cylinders returned from a chemical plant turned out to be hydrogen cyanide, an extremely toxic gas.
- 2. Two men were hospitalized after sniff testing nitrogen cylinders contaminated with chlorine. Fortunately, neither man suffered any after effects of the exposure.
- 3. Another man was sent to a hospital for observation after inhalation of an unidentified gas contained in a nitrogen cylinder returned to the facility for refilling.

The frequency of the above incidents is increasing and points out that a definite and unexpected hazard may be present whenever cylinders are sniff tested for contamination. The hazard can be minimized by following prescribed procedure for sniff testing cylinders. This procedure should be as follows:

- Crack open the cylinder valve and allow only a slight flow of residual gas to escape from the valve.
- 2. Deflect a small amount of this gas with your cupped hand towards your nose which should be at a distance of approximately 12 inches or more from the cylinder valve and generally in a parallel direction with the flow of gas from the valve. DO NOT PLACE YOUR FACE OR NOSE DIRECTLY INTO THE GAS STREAM. The amount of gas being sniffed can be varied as needed by changing the position of the hand in relation to the flow of the gas from the valve.

This procedure will allow the flow of gas to be diluted with the air before it is sniffed and any contamination will be less concentrated. The practice

of placing your nose directly into the stream of gas from the valve must be discontinued as the contamination is most concentrated under these flow conditions.

Each filling plant should be aware that cylinders being returned for refilling may possibly be contaminated with toxic and/or flammable gases or other substances and, therefore, a careful inspection of all returned cylinders is required. As part of the inspection required, each cylinder filling plant should:

- 1. Sniff test all oxygen, nitrogen, argon, and other inert gases for the presence of contaminants.
- 2. Avoid sniff testing of hydrogen and other fuel gas cylinders or specialty gas cylinders identified with a black ring.
- 3. Have set procedures for processing contaminated cylinders when found.
- 4. Where possible, know the application each customer has for cylinders. Particular attention should be paid to cylinders used in special customer processes.
- 5. Whenever possible, determine the source of all contaminated cylinders and advise the customer concerning the receipt of these cylinders from his location and how to avoid recurrence.
- 6. Advise the customer on cylinder safety practices.

SAFETY DEPARTMENT WWSchmoyer/jmf

IV. PHYSICAL, CHEMICAL AND THERMODYNAMIC PROPERTIES

870-8820 Controlled Kinetics Experimentation (J. M. Geist)

Objective: To determine safe operating limits in hazardous systems of interest to Air Products.

A survey was conducted to establish criteria for the design of an impact tester suitable for the testing of the impact sensitivity of materials in liquid oxygen. Two designs are being considered.

Equipment is being assembled to determine the suitability of teflon-hose supported by a braided stainless steel housing for use in high-pressure oxygen service. Tests will be made to compare this hose with the rubber hose which is presently in use.

In cooperation with the Air Plant Components Group, pilot-plant scale runs on removal of carbon dioxide from air by adsorption on molecular sieve were made for Case III (-120°F and 1100 psia). Under the conditions of Case III, the capacity of molecular sieve 13% for carbon dioxide obtained was about 10% by weight of carbon dioxide as compared with arount 15% by weight for Case II (-120°F and 98 psia). Obviously, the sieve used was somehow contaminated, and its capacity could not be restored. Test runs are being continued in the laboratory with small adsorbers to determine the factors affecting the capacity of molecular sieve 13% for carbon dioxide.

Runs were made on the simultaneous adsorption, by silica gel, of acetylene and carbon dioxide from liquid oxygen containing 1.96 ppm acetylene and 2.43 ppm carbon dioxide. Preliminary results indicate that the LOX leaving the silica gel column contained no more than 0.01 ppm of the contaminants, and that the silica gel possessed a desirably high capacity for both acetylene and carbon dioxide before the breakthrough of the contaminants from the adsorber. This activity is being continued to determine the mutual interference of these two contaminants with respect to their adsorption on silica gel.

870-8820 Controlled Kinetics Experiments (J. M. Geist)

Objective: To determine safe operating limits in hazardous systems of interest to Air Products

Designs of impact testers suitable for testing the impact sensitivity of materials in liquid oxygen are being prepared. Cost estimates will be made and selection of the final design will be based on the requirements of the Safety Department.

Three different teflon hoses, supported by braided stainless steel housing, and several rubber hoses of the type normally used by the I & M Division have been tested to determine their suitability for high-pressure oxygen service. The hoses were subjected to sudden oxygen pressures, under clean conditions and under conditions in which iron filings were present, with only slight temperature rises measured as a result of the sudden adiabatic compression. All of the hoses failed as a result of ignition with electric matchheads while pressurized with oxygen. The rubber hose burst and the teflon hose melted. A detailed report will be issued by the Safety Department, and will include recommendation for flexible connections in oxygen service.

Plasite No. 7122H - Cold Set Coating manufactured by the Wisconsin Protective Coating Company of Green Bay, Wisconsin, was tested as a suitable pipe coating for underground lines. Burning tests in oxygen indicated that the paint could be classed as highly flame resistant. The coatings also indicated that the product exceeded our expectations, and it was recommended for service.

An oxygen safety demonstration was presented at Granite City Steel, in conjunction with the Safety Department.

April 1961

RESEARCH and DEVELOPMENT

Monthly Activities Report

87-0-8820 Safety, Hazards and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to API.

The hazards of accumulation of UCON type lubricants in heat exchangers and regenerators were evaluated. UCON oil films on regenerator stones exposed to room temperature air at 400 psig, and ignited with a mild detonator, were found not to turn. These experiments bear directly upon oil contaminated stone-filled regenerators. Pools of oil or heavy thick films would be hazardous.

Steel pipes of 1/4, 1/2, and 1-inch size with an oxygen flow of 1-12 CFM were inited by an acetylene torch. Clean, degreased pipes would stop burning after 1/2 to 2-inch length of pipe was burnt. Dirty, used pipes, and particularly culvanized pipes, burnt longer. The rate of linear burning of the pipe was

proportional to the oxygen flow rate and decreased with increased pipe size.

Larning rates of about 1 ft/min can be obtained with oxygen flow rates of 2 CFM for 1/4-inch pipe, 7 CFM for 1/2-inch pipe, and 13 CFM for 1-inch pipe.

The ignition studies performed in 1956-59 are being reorganized and summarized.

37-0-8820 Safety, Hazards, and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

The standard pressure bombs and spark ignition method using four to six bombs for each sample was used in the following tests:

- 1. About 50% N₂F₂ in NF₃ at 41 psia no reaction.
- 2. About 50% N_2F_2 in NF_3 at 26.5 psia and 26.5 psia of Freon-12 no reaction.
- 3. 91+ % N₂F₂ at 40.8 psia no reaction. Chromatographic analysis confirmed observations.
- 4. Dow Corning fluorinated silicon oils (QF-1-0065) with 100 psig oxygen no reaction.
- 5. Shell polyurethane foam (Epon foam H-60) with 50 psig oxygen no reaction.

The foam was also ignited with matches and an acetylene torch in air and oxygen. One to three seconds after the ignition source was moved away, the foam stopped burning.

A bonfire test was conducted on a cylinder of 91+ % N₂F₂ at 96 psig. After 35 seconds exposure, the cylinder safety disc melted and the gas was released without explosive or damaging effects.

87-0-8820 Safety, Hazards, and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

- 1. The spark ignition used in the standard bomb test failed at oxygen pressures above 70 psig due to the increased resistance in the gas phase and the small thickness of the insulation, so that above 70 psig pressure the current leaked through the insulation. Another ignition method, insensitive to gas pressure, was developed. It uses a small thin resistance wire that is partly vaporized by a low voltage surge.
- 2. Led Plate 251, pipe dope, was tested by rapid compression of high pressure oxygen. One test out of 23 resulted in an explosion. This material is unsafe for use in oxygen service.

87-0-8321 Safety, Hazards, and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

The development of the vaporized wire igniter was continued. The sensitivity of the method will be determined in November.

Six series of tests, each with six pressure bombs, were made with the batch of N_2F_2 that was involved in the August accident. Blanks and rust showed no reaction. Kel-F shavings, Fluorolube, polyethylene, and air reacted with the gas. At the cylinder pressure 13-23 psig no explosions were obtained.

Pine and maple wood cubes were saturated with LOX and ignited with a No. 6 blasting cap. Powerful detonations of the same magnitude for both woods resulted. More LOX is adsorbed in maple than in pine.

Activated carbon with the same amounts of adsorbed gas, at liquid nitrogen temperature, with different oxygen-nitrogen compositions was ignited with No. 6 blasting caps. Very powerful detonations resulted with pure LOX. The mixtures detonated, but more mildly, even at concentrations of 9% oxygen and oxygen to carbon ratio of 2% of stoichiometric.

87-0-8821 Safety, Hazards, and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

The development of the standard ignition test method was continued and a progress report was issued. The results obtained with gaseous oxygen are encouraging. The method is sensitive and reproducible. In its present form this test method cannot be used for testing in liquid oxygen. Work is continuing on the determination of the sensitivity of the tests and on application to liquid oxygen. A new, high pressure, externally operated manifold was added to the ignition cell.

The possibility of initiation of ignition by shock waves is being studied.

The following materials were tested with high pressure oxygen (2000 psig) and were found non-compatible with high pressure oxygen.

Silicon Oils. Dow Corning RF-1-0065, 1000 C.S. (6 tests).

Silicon Oils. Dow Corning RF-1-0065, 10,000 C.S. (3 tests).

Indopol Polybutene Oil. Amoco L-10 (6 tests).

Indopol Polybutene Oil. Amoco H-100 (1 test).

Penton, shavings of the solid material (6 tests).

Penton was found to be only slightly affected by soaking in acetone.

The following material was tested and determined compatible with high pressure oxygen: "T" film thread compound. This material, however, corrodes brass.

MONTHLY ACTIVITIES REPORT
RESEARCH and DEVILOPMENT DEPARTMENT

Air Products and Chemicals

December 1961

87-0-8821 Safety, Hazards, and Explosion Testing (E. Kehat)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

The development of the standard ignition test method was continued and a progress report will be issued in the first week of January. The method is more sensitive than LOX Impact Testers and more reproducible. Work is continuing on the use of this method at low temperatures.

Other tests made during the month were:

1. CS₂

- a. Solidified CS2 in IOX ignited with a blasting cap detonated with a powerful blast.
- b. CS2 showed high sensitivity in the standard ignition test.

In two of the tests, the CS2 ignited spontaneously as high pressure oxygen was introduced into the bomb.

- 2. Aliquippa pump suction filter defrost. Both oil and solvent (methylene chloride) showed high ignition sensitivity in our standard ignition test.
- Cyl-Seal sealing compound -- was tested and found incompatible with oxygen.

87-0-8821 Safety, Hazards, and Explosion Testing (E. Kehat and R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

The development of the standard ignition test method was continued and the results of these tests were reported in a memorandum by E. Kehat on January 3, 1962. The results compare favorably with those of the LOX Impact Testers. The equipment is inexpensive and simpler and the test is more sensitive than the impact test.

Other tests made during the month included:

- (1) APL piping residue submitted by L. Ball. A small sample of material of unknown content found in oxygen lines at APL was submitted for ignition testing. One test showed no reaction and in two remaining tests, the material detonated upon ignition. Therefore, the material is classified unsafe.
- (2) Methylene chloride submitted by the Safety Department. The compatibility of methylene chloride in high pressure air surfaces was checked at the request of the Safety Department.

There was no apparent reaction in six consecutive samples subjected to the test. A plot of the flammability limits of methylene chloride-oxygen-nitrogen mixtures shows that methylene chloride and air should not ignite. It was agreed that methylene chloride is safe for use as a cleaning agent in high pressure air systems.

Several small changes were made in operating procedures and in the design of the ignition system to improve the reliability and ease of operation. The comparison tests of this system with the data from LOX Impact Testers are continuing and is being extended as rapidly as possible.

February 1962

MONTHLY ACTIVITIES REPORT
RESEARCH and DEVELOPMENT DEPARTMENT

Air Products and Chemicals

87-0-8821 Safety, Hazards, and Explosion Testing (R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

Several small improvements were made in the design and operation of the ignition test apparatus to make the testing easier and more informative. A safety valve set at 150 psig was added to the ignition chamber piping to relieve extreme pressures which developed with some of the previous detonations. A rubber balloon seals the outlet of the valve to permit view of the volume of gas generated during the ignition period. In addition, Teflon cups are now being used to contain the sample in order that the ignition electrodes will not be inadvertently shorted to the chamber walls.

Additional samples were tested at the request of various departments.

"Florube" grease, received from APL through the Safety Department, was declared tentatively satisfactory for oxygen service. Four of six samples gave no reaction; two showed a slow pressure rise. In none of these six cases was the sample damaged, but in the two positive tests, the Teflon suffered damage. Since this reaction of Teflon in the presence of fluoring compounds has been noted by other investigators, additional tests will be made with another chamber-sealing medium.

At the request of the Manufacturing Department, two epoxy compounds which are being considered for cementing bubble caps into trays were tested. Both Devcon "2 ton" and Devcon "F" gave positive results in all samples and are definitely unsuitable for oxygen service.

Because of the obvious advantages in the use of foam type insulations on various laboratory projects, tests were performed on both Styrofoam and a polyurethane foam insulation samples. Both gave extremely violent reactions in oxygen. These materials are not to be considered for service where liquid and gaseous oxygen will be present. Similar tests of these materials in air are being prepared.

Raybestos Manhattan packing, an impregnated asbestos rope material, was tested at the request of the manufacturer and found unsuitable for oxygen service by this method.

March 1962

MONTHLY ACTIVITIES REPORT
RESEARCH and DEVELOPMENT DEPARTMENT

Air Products and Chemicals

87-0-8821 Safety, Hazards, and Explosion Testing (R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

A cast polyester resin impregnated fiberglass plastic container which had exhibited considerable promise for satisfactory use at liquid oxygen and nitrogen temperatures was submitted for testing in the R&D ignition apparatus. Tests made on filings of this material resulted in explosions, while chunks of the cast material produced only a slight pressure rise in the test system. The material does, however, burn in open air. In its present configuration it is not satisfactory for oxygen service. Further tests were conducted in the attempt to devise a liquid phase test giving reproducible results.

The apparent interaction of some fluorine-containing compounds with Teflon sealant has caused the investigation of other sealants such as the lava material used with some thermocouple designs.

Tests relating this ignition method with the spark system used in the hydrocarbon film ignition tests performed under the liquid oxygen contamination program are continuing.



87-0-8821 Safety, Hazards, and Explosion Testing (R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

Camples of EPON H-60, Polycel 440R and Styrofoam were tested at high and low oxygen pressures. Reaction was violent at the high level, minor in the low pressure test.

Two aerosol-type lubricants, Moly-Spray Kote and Dri-Lube, were tested. Although a slight reaction was noted in the bomb, the lubricant appeared unharmed. It is believed that residual lubricant caused the difficulty. Further tests will be conducted.

June 1962

MONTHLY ACTIVITIES REPORT
RESEARCH and DEVELOPMENT DEPARTMENT

Air Froducts and Chemicals

87-0-8821 Safety, Hazards, and Explosion Testing (R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

Torch ignition tests were run on a Houdry foam insulation, and on a Haveg glass fiber-reinforced plastic. Both were self-extinguishing in air, but burned brightly in 100% oxygen after removal of the torch flame. These materials are not satisfactory for use in oxygen service.

July 1962

87-0-8821 Safety, Hazards, and Explosion Testing (R. H. Foster)

Objective: To determine safe operating limits in hazardous systems of interest to APCI.

A sample of talcum powder proposed as a lubricant for wire pulling was found to be satisfactory for oxygen service. "Tarset," an epoxy-based pipe coating, was checked for its combustibility when used as a coating on pipes carrying oxygen. Pipes were coated; the open end then raised to ignition temperature; and oxygen flow was started. The coating produced little effect on the pipe-burning rates. Photographs and movies of the tests were forwarded to the Safety Department. This material exhibited application characteristics similar to "Plasite," which was tested previously. "Plasite" appears to be more economical than "Tarset."

Equipment is now being assembled to perform tests on the sensitivity of carbon disulfide in liquid oxygen for project 03-2-3310.

March 1963

MONTHLY ACTIVITIES REPORT
RESEARCH and DEVELOPMENT DEPARTMENT

Air Products and Chemicals

87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

An oxygen pressure transmitter was tested for explosion hazards for U.S. Gauge. A pressure of 10,000 psig failed to burst its bourdon tube. Exposure of the gauge case to 1,200 psig resulted in its bursting, even though it was equipped with a relief device. This was not interpreted as an explosion.

No explosive reactions were obtained with TWF wool and spintex 305 in gaseous oxygen when initiated with a hot wire.

Two samples of molykote were tested for high pressure oxygen compatibility. Type Z, a dry lubricant, gave one reaction during five tests. Type X-15 gave one reaction out of six tests.

MONTHLY ACTIVITIES REPORT

RESEARCH and DEVELOPMENT DEPARTMENT

Air Products and Chemicals

May 1963

87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

WO-80-0099 Kel-F

Samples of Kel-F polymer and nylon were compared for oxygen compatibility by exposure with hot wire ignition to gaseous oxygen at 2000 psi and ambient temperature. The samples were shredded and washed with methylene chloride prior to testing. Nylon is much more reactive than Kel-F. Only

two nylon tests were made as the bombs were ruptured violently in both tests. The Kel-F sample gave five reactions out of five tests, as indicated by an increase in temperature and pressure. Even though the Kel-F polymer is not compatible, it is much safer than nylon.

WO-10-6285 Oxygen Compatibility of Various Cutting Oils

A spectrum of cutting oils was analyzed by IR and the oils placed into four groups based on their functionality. Composite blends were made of the members of each group and will be used to determine reactivity with high pressure gaseous oxygen as a function of oil film thickness.

87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

IWO 10-2010

Decolorized halocarbon compressor oil was submitted for determination of its oxygen compatibility. It was suspected that the residue decolorizing the oil might present an explosion hazard. Five tests were run in brass bombs at 2700 psig of oxygen and 350°F, attempting to simulate as closely as possible the actual operating conditions in the compressor. No reaction was observed to take place in any of the test bombs — indicating that the oil in its present state is safe for continued use.

Molylube 99

Molylube 99 was tested for gaseous oxygen compatibility at 2000 psig and room temperature. In the five tests run there were no signs of reaction. These results contrast to tests that were run on Molykote types Z and X-15 wherein reaction occurred.

Two samples of Cabosil M-5 were tested for liquid oxygen compatibility and found to be inert.

IWO 81-0062

A sample of a formica laminate bonded with a phenolic resin was submitted for complete oxygen compatibility testing. At 2000 psig and room temperature reaction was obtained in four out of four test samples, as signified by charring on the surface of the formica. Scraping the charred surface revealed that reaction had taken place only at the surface. Four tests were run in liquid oxygen using hot wire igniters and gave no apparent reaction. Evidently at liquid oxygen temperatures, the structure becomes impregnable to oxygen and is, therefore, inert.

IWO 10-6285

A program is being conducted to determine the allowable concentration limit in milligrams per square foot of various types of cutting oils. Hexadecane has been run as a standard. It was found that at 500 milligrams per square foot, reaction was obtained but cocci



no noticeable reaction occurred at 400 milligrams per square foot. The hydrocarbon type cutting oils, known as Type Group II, were run first since the group represents 50% of the cutting oils to be studied. At 400 milligrams per square foot, a violent detonation occurred; while at 300 and 250 milligrams per square foot, very intense fires occurred on the wall of the test vessel. Lower concentrations will be tested with this sample of mixed cutting oils to determine at what level no reaction occurs.

Plant Wash-Out Studies

A study has been commenced to determine the explosion hazard that may be represented by Cellulube 300 when deposited in the high-pressure air circuit and high-pressure section of the distillation column in the 75 T/D air plants. It has been found that Cellulube 300 detonates at 2000 psig in the presence of pure oxygen when a hot wire igniter is used and produces a fire at 50% oxygen but gives no reaction at 32% oxygen. The experiment was conducted at 2000 psi with 32% oxygen in order that the partial pressure of oxygen would be 640 psi, approximately the same as it actually is in the plant high-pressure circuit containing air at about 3000 psi. With liquid oxygen and placement of the igniter above the oil-LOX interface, reaction occurs giving a fire but not a detonation. With 32% liquid oxygen in nitrogen no reaction occurs in a test setup similar to the foregoing. The 32% oxygen concentration was selected to correspond to a typical "crude" oxygen bottom for the high-pressure column. These results indicate that the chance of explosion in the high-pressure distillation column is small. Detonations that have occurred in the warm highpressure air circuits may be associated with pressure surges which cause the oil to be atomized, permitting a vapor detonation. Work will be continued to determine the reactivity of Cellulube 220 and further verify the effects of oil film concentrations, ignition conditions, and mode of dispersal on the reactivity of these Cellulube oils in the presence of 32% oxygen.

87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

75 T/D Plant Wash Out Studies

The purpose of this study is to aid in determining the necessity of washing out the 75 T/D and other size oxygen plants. The main contaminant, which has been found to appear in the high-pressure air section of these plants, is Cellulube 300, while a mixture of Cellulube 300 and DTE-103 (the oil used to lubricate the expansion turbine) is found in the high-pressure section of the distillation column. The work described is a study of the explosion potential of Cellulube 300, 200, and DTE-103 in the presence of high-pressure gaseous air and oxygen and liquid air and oxygen.

At ambient temperature Cellulube 300 contained in a Teflon cup, exposed to 2000 psig 32% oxygen in nitrogen gas mixture, and initiated with a fused wire located at the oil gas interface did not react. Cellulube 300 contained in a cup in similar fashion and covered with an enriched liquid air containing 32% oxygen also did not react when subjected to fused wire ignition.

In an attempt to determine the effect of adverse operating conditions on the possible explosion hazard of Cellulube 300, a test was run at $350^{\rm o}{\rm F}$ and 2500 psig in the presence of 32% oxygen and at a Cellulube concentration of 3.5 g/ft² again using the fused wire igniter. Under these conditions a reaction did take place as was signified by the appearance of charred matter on the walls of the bomb.

In an attempt to simulate the effect of valve failure, Cellulube was atomized into the test bomb by rapid pressurization. Fused wire ignition simultaneous with injection of the oil and 32% air into the test cell gave no apparent reaction.

The only additional experiment to be performed is the determination of the effect of disbursement on the explosion potential of Cellulube 300 in the presence of liquid air.

Although these results are preliminary, in that a statistical series has not been run for each of the significant tests, they seem to indicate that no hazard exists in the high-pressure air circuit or high-pressure section of the distillation column, as long as Cellulube or DTE is the sole major organic material present. There is a possibility though of reaction taking place in the compressors or intercooler sections associated with the compressors, since elevated temperatures do exist in these areas.

Study of the Recent Fires at DuPont New Johnsonville Plant

Recently, two fires occurred at separate times in the New Johnsonville oxygen plant. The first occurred in the aftercooler system; the second in the compressor oil demister tower. Various questions were posed as to the source of these fires and what effect the presence of titanium might have on increasing the probability of combustion reactions taking place.

A search of the literature showed that TiO₂ is not generally recognized as an oxidation catalyst and would be rated very low in a series of metal ozides as to its ability to promote oxidation reactions. Since no data were available as to the thermal stability of DTE-103 or Solnus 500 (a similar type hydrocarbon oil which could be used in place of DTE-103), a destructive distillation test was run to determine the relative stabilities of these two oils. As vaporization takes place, oxidative cracking also occurs resulting in the formation of a non-volatile residue. The weight of this residue was determined and is reported as grams of residue per gram of sample. This test was run on both Solnus 500 and DTE-103 and then repeated with the addition of a film of TiO₂ on the surface of the aluminum cups. The film was added by placing TiCl₄ on the surface of the cup and allowing it to react with atmosphere. The following table shows the average results of the three runs made in each case.

	Residue in g/g of Sample			
Oil	Standard	Plus TiO2		
DTE-103	0.0112	0.0291		
Solnus 500	0. 0095	0.0067		



In comparing these results, there is only a slight difference between the carbon residue formed by Solnus 500 and DTE-103 when decomposed by themselves, but a very large difference occurs when the decomposition takes place in the presence of TiO₂. Both oils react vigorously with TiCl₄ to give a dark brown residue; DTE-103 giving the more residue of the two oils.

No catalytic effect was observed for TiO₂ when Solnus 500 was reacted with air at 1800 psig. There is considerable evidence though that TiO₂ will promote the thermal cracking of DTE-103. The products of this thermal cracking reaction would be unsaturated and much more susceptible to oxidation than the pure oil. Based on these facts, it is hypothesized that TiO₂ or titanium oxy chlorides is being drawn into the plant through the filter system and is promoting the thermal decomposition of the compressor oil. This results in the formation of new compositions of matter which are much more readily oxidizable, as well as more volatile, and could possibly have accumulated in the sections of the plant where the fires took place. Since these materials are unsaturated, they are more susceptible to autoxidation and spontaneous combustion could have taken place. Due to the better stability of Solnus 500 in the presence of TiO₂, it is recommended that this oil be used in place of DTE-103.

September 1963



87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

75 T/D Plant Wash Out Study

The purpose of this study is to aid in determining the necessity of washing out the high pressure air circuit and distillation column of the 75 T/D and other size oxygen plants. The main contaminants which have been found in these sections are Cellulube 300 and DTE 103.

The tests were run using a fused wire ignition system and an enriched air mixture containing 32% oxygen with the Cellulube or DTE sample frozen in a teflon cup and the igniter at the liquid air oil interface. No effect of pressure on reactivity was observed when these tests were run at 100 psig instead of atmospheric pressure. In order to determine the effect of degree of disbursement of Cellulube 300 in enriched air, fine frozen particles of the oil were placed in a teflon cup and mixed with the 32% liquid oxygen. Ignition did not result in any reaction, as was also the case when Cellulube was in the form of a single large particle. The results of these tests continue to indicate that no reaction hazard exists in the high pressure air circuit or the high pressure section of the distillation columns in the 75 T/D plants due to the presence of either Cellulube 300 or DTE 103.

Study of the Recent Fires at DuPont New Johnsonville Plant

The purpose of this work is to aid in determining the source and possible means of preventing reactions which have recently taken place in this plant. The major difference between this plant and most others that we operate is the presence of titanium oxide in the atmosphere.

Previous work has compared the relative stability of Solnus 500 and Cellulube 300 towards heat and the presence of titanium. This comparison is continued examining their reactivity as a function of oil concentration with high pressure air and oxygen. In the presence of air Cellulube does not react regardless of its concentration level, and a very mild reaction was observed with Solnus 500 at 3500 mg/ft. In the presence of pure oxygen at 2000 psig using a fused wire igniter, Solnus 500 did not react at 15 mg/ft but it did react at 30 mg/ft. Cellulube 300 did not react at 200 mg/ft but did react at 250 mg/ft. These results indicate that Cellulube 300 is more stable towards

combustive oxidation reactions than Solnus 500, even though Solnus 500 gave larger quantities of residue on destructive distillation and was more reactive with ${\rm TiCl}_{l_1}$. This is understandable since Cellulube is a polyphosphate ester and phosphorous is a known oxidation inhibitor, but its presence could account for both the increase in residue and reactivity with ${\rm TiCl}_{l_1}$.

An experiment was run examining the effect of TiO₂ on the reactivity of Cellulube 300 with air at 1750 psig. No reactions were observed with or without titanium.

July 1963

87-0-8822 Flammability and Explosion Hazards (R. A. Walde)

Objective: To provide routine experimental evaluation of the hazards involved in processing and handling present or potential company products.

Plant Wash-Out Studies

Previous tests indicated that Cellulube 300 was compatible with liquid and gaseous 32% oxygen. A test was run to determine if Cellulube 220 exhibited the same inertness. The test was run using 32% oxygen at 2000 psig and did not give any reaction.

To determine the effect of concentration of Cellulube 300 on its compatibility with 32% oxygen, a test was run wherein the sample was placed in a cup just below the hot wire igniter. There was no apparent reaction in this test. It has been found, however, that reaction will take place between Cellulube 300 and 32% oxygen at 2500 psig and 300°F. A test run at these conditions showed evidence that a mild combustion had taken place in the bomb.

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Air Products and Chemicals QUALITY CONTROL LAYOUT

Number: QCL 101F

Effective: 7/1/71 Page: 1 of 2

Supersedes: 4/14/69

CLEANING REQUIREMENTS FOR AIR PLANT EQUIPMENT

I. PURPOSE AND SCOPE

This QCL lists the cleaning classifications which will apply to components and/or circuits of air plants to provide adequate cleanliness.

Where special requirements apply to an item and/or assembly, they shall take precedence over this QCL.

II. GENERAL

There are four classifications used by Air Products and Chemicals, Inc. to indicate specific degrees of cleanliness. These classifications - listed in decreasing order of magnitude - are identified as Class AAA, Class AA and Class B. They are defined as follows:

- A. Class AAA cleaning. Class AAA is the most stringent standard cleaning classification. It is normally applied to reciprocating compressors, pumps, valves, etc., which will, thru use, contact liquid or gaseous oxygen. Acceptance criteria for Class AAA cleaning are listed in QCL 107F and QCL 117F. *
- B. Class AA cleaning. Class AA is the more generally applied standard cleaning classification. It is applied to most shop fabricated or purchased equipment where fixed surfaces will, thru use, contact liquid or gaseous oxygen. Acceptance criteria for Class AA cleaning are listed in QCL 106F and QCL 116F.
- C. Class A cleaning. Class A is the most relaxed standard cleaning classification applied to equipment which will, thru use, contact an oxygen rich atmosphere or a product fluid. Acceptance criteria for Class A cleaning are listed in QCL 105F and QCL 115F.

^{*}Typing error corrected 5/10/72

Number :

QCL 101F

Effective:

7/1/71

Page : Supersedes :

2 of 2 4/14/69

CLEANING REQUIREMENTS OF AIR PLANT EQUIPMENT

(Note: Equipment intended for a pure product fluid service rather than oxygen [such as nitrogen] that may, thru use, be converted to liquid or gaseous oxygen service shall be cleaned to the proper classification of oxygen cleaning.)

D. Class B cleaning. Class B is the standard cleaning classification which is normally applied to equipment which will not contact liquid air, oxygen enriched atmosphere or product fluids. Acceptance criteria for Class B cleaning are listed in QCL 104F and QCL 114F.

III. APPLICATION

- A. Proper application of cleaning classifications will be determined from the following:
 - 1. QCL's 104F, 105F, 106F and 107F are normally applied to materials cleaned by Air Products and Chemicals, Inc.
 - 2. QCL's 114F, 115F, 116F and 117F will apply when the material is cleaned by the supplier.
- B. Specified cleaning classifications for various circuits and/or components are listed in the attachment to this QCL.

ATTACHMENT TO QCL 101F

REQUIRED CLEANING Vendor Cleaned 117F 116F 115F 114F 107F 106F 105F 104F APCI Cleaned В AAA AA Α 1. Air Circuit В 1.1 Air Drier В 1.2 Carbon Dioxide Adsorbers В 1.3 Caustic Purifiers 1.4 Compressors В 1.4.1 Coolers В 1.4.2 Separators В 1.4.3 Surge Tanks В 1.4.4 Condensate Traps В 1.5 Condensate Traps 1.6 Exchangers В 1.6.1 Air Precoolers В 1.6.2 Freon-Air Exchangers В 1.6.3 Main Air Exchangers 1.7 Expanders В 1.7.1 Expander Oil Adsorbers 1.8 Filters В 1.8.1 Air Drier Filters В 1.8.2 Expander Oil Adsorber Filters В 1.9 Piping Upstream of A-1 В 1.10 Regenerators В 1.11 Separators В 1.12 Valves up to the A-1 Valve

		Vendor	Cleaned	117F	116F	115F	 114F
			leaned	107F	106F	105F	104F
				AAA	AA	A	В
2.	Liqu	id Air Circuits					
	2.1	Piping downstream of A-1 Valve up to					
		the high pressure column				A	
	2.2	Receivers				A	
	2.3	Valves including A-1 valve and up to					
		the high pressure column		AAA			
3.	Crud	e Oxygen or Oxygen Enriched Circuits					
	3.1	CO2 Filters and Adsorbers					
		(Crude Oxygen Circuit)				A	
	3.2	High Pressure Column Components and A	ssembly			A	
	3.3	Hydrocarbon Adsorbers				A	
	3.4	Subcoolers, Crude 02 Side				A	
	3.5	Phase Separators				A	
	3.6	Piping up to the Hydrocarbon Adsorber	Inlet			A	
	3.7	Valves up to the Hydrocarbon Adsorber	S	AAA			
	3.8	Piping downstream of the Hydrocarbon	Adsorbers			A	
	3.9	Valves downstream of the Hydrocarbon	Adsorbers	AAA			
	3.10	Expanders processing Oxygen Enriched	Air		AA		
4.	Liqu	id and Gaseous Oxygen Circuits					
	4.1	Column Components and Column Assembly			AA		
	4.2	Charging Manifolds			AA		
	4.3	Compressors					
		4.3.1 Reciprocating		AAA			
		4.3.2 Centrifugal			AA		

		Vendor Cleaned	117F	116F	115F	114F
		APCI Cleaned	107F	106F	105F	104F
			AAA	AA	A	В
4.4	Expanders			AA		
4.5	Instrumentation					
	4.5.1 Flowmeters (Turbine or					
	Displacement)		AAA			
	4.5.2 Rotameters		AAA			
	4.5.3 Others			AA		
4.6	Phase Separators			AA		
4.7	Pumps		AAA			
4.8	Piping			AA		
4.9	Reboiler Condensers					
	4.9.1 Pot Type			AA		
	4.9.2 Thermo Siphon			AA		
4.10	Storage Tanks (Inner Surface)			AA		
	4.10.1 Double Jacketed Tanks	(Outer				
	Surface of Inner Tank	and				
	Inner Surface of Outer	Tank				
	-Particle Size Require	ments				
	are Waived)				A	
4.11	Storage Tubes			AA		
4.12	Subcoolers			AA		
4.13	Valves (Check, Control, Hand a	and Safety)	AAA			
4.14	Vaporizers			AA		
4.15	Vents				A	
. Nitr	ogen Circuits					

5.

5.1 Reactivation Circuits

								-
				Vendor Cleaned	117F	116F	115F	114F
				APCI Cleaned	107F	106F	105F	104F
					AAA	AA	A	В
		5.1.1	Drier and Oil Adsorber	Reactivation				
			Heater and Piping					В
		5.1.2	CO2 and Hydrocarbon Ads	orber Reactivation	n			
			Heater and Piping				A	
	5.2	Nitrog	en Side of Reboiler Cond	ensers			A	
	5.3	Nitrog	en Phase Separators and	piping				
		supply	ing Reflex to the Column	ı			A	
	5.4	Subcoo	lers, Reflux Nitrogen				A	
	5.5	Other	Piping					В
6.	Defr	ost Cir	cuits					
	6.1	Heater					A	
	6.2	Piping	(Circuits should be cle	aned to				
		the cl	eanliness required by th	e circuit				
		to be	defrosted.)					
	6.3	Vent S	tacks					
7.	By-P	roducts	Circuits (Argon and Oth	ers)				
	7.1	Column	8				A	
	7.2	Conden	sers				A	
	7.3	Piping	;				A	
	7.4	Separa	tors				A	
	7.5	Valves	ı		AAA			
8.	Pure	Produc	t Circuits (Other than O	xygen)				
	8.1	Instru	mentation			AA		
	8.2	Chargi	ng Manifolds				A	
	8.3	Piping	\$				A	
						Page	4 of 5	

			Vendor Cleaned	117F	116F	115F	114F
			APCI Cleaned	107F	106F	105F	104F
				AAA	AA	A	В
	8.4	Storage Tanks				A	
	8.5	Storage Tubes	-			A	
	8.6	Pumps			AA		
	8.7	Vaporizers				A	
	8.8	Valves		AAA			
9.	Serv	ice Circuits					
	9.1	Refrigeration					В
	9.2	Steam					В
	9.3	Water					В





Number : Effective :

QCL 102F 7/1/71

Page:

1 of 3 4/14/69

CLEANING REQUIREMENTS

Supersedes:

FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

I. PURPOSE AND SCOPE

This standard lists the cleaning requirements for bourdon tube type gages used in liquid or gaseous oxygen circuits. It applies whenever a specification or order requires that this type gage be cleaned for oxygen service.

II. CLEANING SOLVENTS

- A. Technical grade methylene chloride or neutral, stabilized trichlorethylene shall be used to clean.
- B. Use of other solvents will require written approval from Quality Control or the Safety Department prior to cleaning.

. III. PROCEDURE

- A. Use any method which will insure complete tube fill, total solvent removal, and which will allow analysis of the effluent. Suggested procedure to accomplish manual calenaing is as follows:
 - 1. Place the gage so that the presssure inlet is facing up.
 - 2. Use a hypodermic needle with graduated syringe to accomplish fill.

 Gently tap the gage during the operating to encourage fill.
 - 3. Empty the solvent into a clean graduated container. Compare the amount of solvent removed with the quantity introduced (2 above) to determine complete removal.
 - 4. Examine the effluent for contamination. Continue the cleaning process until acceptance (per par. IV) is possible.



Number :

QCL 102F

Effective : Page :

7/1/71 2 of 3 4/14/69

CLEANING REQUIREMENTS

Supersedes:

FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

IV. QUALITY REQUIREMENTS

- A. In a darkended area, use ultrviolet light (3200 to 4000 a.u. wavelength) to examine the effluent. Compare the result with an ultraviolet examination of a sample of unused solvent. A noticeable increase in fluorescence of the used solvent will require that additional cleaning be performed.
- B. After the effluent is determined hydrocarbon free (per A above), pass the used solvent thru a filter to detect the amount and size of solid matter in the solvent. Use Whatman #44, or equal, filter paper.
- C. After the solvent has completely evaporated from the filter paper, examine the residue. Solid matter is limited to:
 - 1. No particle larger 1000 microns (.040") in size. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
 - 2. Not more than five particles between 500 and 1000 microns.
 - 3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.
- D. When the effluent is found acceptable, purge the bourdon tube with dry, oil free air or nitrogen. Sniff the inlet after purge to determine solvent removal.



Number: QCL 102F

Effective:

7/1/71 3 of 3

Page: Supersedes:

4/14/69

CLEANING REQUIREMENTS

FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

V. SEAL AND IDENTIFICATION

Gages cleaned in accordance with this standard shall be labeled to indicate oxygen service cleanliness, and require suitable seal to prevent contamination.

- 1. Seal shall consist of a nondeteriorating, inert, greaseless barrier material.
- 2. The cleanliness label shall not interfere with usability of the gage.



Number : Effective :

QCL 104F 7/1/71

Page:

Supersedes:

1 of 1 4/14/69

CLASS B CLEANLINESS REQUIREMENTS

I. PURPOSE

To list acceptance criteria for product cleaned to Class B by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of the standard apply to surfaces which thru use do not contact liquid air, oxygen enriched atmosphere or product fluids.

Materials, components and/or assemblies of process equipment with specified Class B cleaning, or with no cleaning requirement listed, will be determined acceptable by this standard.

III. QUALITY REQUIREMENTS

The Plant Inspection Supervisor will insure adequate cleanliness. Visual inspection of the direct surface under bright white light shall indicate:

- A. No evidence of moisture.
- B. No accumulation of loose rust, scale or other foreign matter.
- C. Free of easily visible films or accumulations of organic materials, such as oil, grease, paint and similar materials.

IV. RELATED PROCEDURES

QCL 101F lists correct application of this standard for air plant components.

Air Products and Chemicals QUALITY CONTROL LAYOUT

Number: QCL 105F Effective: 7/1/71

Page: 1 of 3 Supersedes: 4/14/69

CLASS A CLEANLINESS REQUIREMENTS

I. PURPOSE

To list criteria to be used for acceptance of product cleaned to Class A by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to surfaces which thru use contact fluid other than pure oxygen. Examples are: argon, liquid air, crude oxygen, hydrogen, nitrogen, etc.

III. RESPONSIBILITY

- A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification, the need for Class A cleaning as appropriate.
- B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods, as necessary, to determine adequate cleanliness. Other methods which experience shows more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

- a. Examine the surface under bright white light for visible contamination.
- b. Examine the surface under ultraviolet light (3660 a.u. wavelength) for organic contamination.

Air Products and Chemicals QUALITY CONTROL LAYOUT

Number: QCL 105F Effective: 7/1/71

Page: 2 of 3 Supersedes: 4/14/69

CLASS A CLEANLINESS REQUIREMENTS

c. Wipe the surface with clean filter paper or lint-free cloth and examine for contamination.

2. Inaccessible Surfaces

Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Free of loose (or potentially loose) rust, scale or other foreign matter.
 - 3. Free of slag and weld spatter.
 - 4. Essentially free of organic material, such as oil, grease, crayon, paint, etc.
- B. Ultraviolet (3660 a.u. wavelength) examination shall show the surface:
 - 1. Essentially free of fluorescence.* Isolated particles of lint and small area of low intensity fluorescence are acceptable.
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media except that which is due to oxidation of the parent metal.
 - 2. No evidence of oily residue.
- * Typing error corrected 5/10/72

Number: QCL 105F Effective: 7/1/71

Page: 3 of 3 Supersedes: 4/14/69

CLASS A CLEANLINESS REQUIREMENTS

- D. Particle population per square foot of surface tested must conform to the limits listed below. (A 100 ml. approximately 3.5 oz. sample of flush solution may be considered as representing the rinse of one square foot of enclosed surface.) Contamination per square foot is limited to:
 - 1. No particle larger than 1500 microns (approx. 1/16 inch). A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
 - 2. Not more than ten particles between 750 and 1500 microns.
 - 3. No fiber in excess of 6000 microns (approx. 1/4 inch), and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

VI. RELATED FORMS

- A. Record of an inspection will be listed on Form 1086, or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.
- B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to cryogenic components.

(Retyped 9/21/72 db)

Air Products and Chemicals QUALITY CONTROL LAYOUT

Number:

OCL 106F

Effective : Page :

7/1/71 1 of 3

Supersedes:

4/14/69

CLASS AA CLEANLINESS REQUIREFENTS

I. PURPOSE

To list criterial to be used for acceptance of product cleaned to Class AA by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to <u>fixed</u> surfaces which thru use contact pure oxygen.

III. RESPONSIBILITY

- A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification the need for Class AA cleaning as appropriate.
- B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods as necessary to determine adequate cleanliness. Other methods which experience shows to be more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

- a. Examine the surface under bright white light for visible contamination.
- b. Examine surface under ultraviolet light (3660 a.u. wavelength) for organic contamination.
- c. Wipe surface with clean filter paper or lint free cloth and examine for contamination.

Number: QCL 106F Effective: 7/1/71

Page: 2 of 3

Supersedes: 4/14/69

CLASS AA CLEANLINESS REQUIREMENTS

d. Rinse surface with clean solvent and examine the effluent for contamination.

2. Inaccessible Surface

a. Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Essentially free of corrosion products.
 - 3. Free of scale, slag, weld spatter and other foreign matter.
 - 4. Free of organic material such as oil, grease, crayon, paint, etc.
- B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:
 - 1. No hydrocarbon fluorescence.
 - 2. Isolated particles of lint* are acceptable.
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media, except that due to oxidation of the parent metal.
 - 2. No evidence of oily residue (not detectable by A or E above).
- D. Particle population per square foot of surface tested must conform to the limits listed below. (A 100ml. approximately 3.5 oz. sample of flush solution may be considered as representing the rinse of one* square foot of enclosed surface). Contamination per square foot is

limited to:

^{*}Typing errors corrected 5/10/72

Number :

QCL 106F

Effective : Page :

7/1/71 3 of 3

Supersedes :

4/14/69

CLASS AA CLEANLINESS REQUIREMENTS

1. No particle larger than 1000 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.

- 2. Not more than ten particles between 500 and 1000 microns.
- 3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

IV. RELATED FORM'S

- A. Record of an inspection will be listed on Form 1086; or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.
- B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to cryogenic components.

Number :

ନ୍CL 107F

Effective : Page :

7/1/71 1 of 3

Supersedes:

4/14/69

CLASS AAA CLEANLINESS REQUIREMENTS

I. FURPOSE

To list criteria to be used for acceptance of product cleaned to Class AAA by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to components with <u>movable parts</u> which thru use contact liquid or gaseous oxygen. Valves in pure product circuits other than oxygen, and in by-product (argon and others) circuits are included.

III. PESPONSIBILITY

- A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification, the need for Class AAA cleaning as appropriate.
- B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods as necessary to determine adequate cleanliness. Other methods which experience shows to be more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

- a. Examine the surface under bright white light for visible contamination.
- b. Examine surface under ultraviolet light (3660 a.u. wavelength) for organic contamination.

Number: QCL 107F Effective: 7/1/71

Page: 2 of 3 Supersedes: 4/14/69

CLASS AAA CLEANLINESS REQUIREMENTS

.. Wipe surface with clean filter paper or lint free cloth and examine for contamination.

d. Rinse surface with clean solvent and examine the effluent for contamination.

2. Inaccessible Surface

a. Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Free of corrosion, scale, slag, weld spatter, and other foreign matter.
 - 3. Free of organic materials, such as oil, grease, crayon, paint ink, etc.
- B. Ultraviolet (3660 a.u. wavelength) inspections shall indicate:
 - 1. No hydrocarbon fluorescence.
 - 2. Complete removal of lint. If present, use nitrogen or dry oilfree air for removal.
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media.
 - 2. No evidence of oily residue (not detectable by A or B above).

Number: QCL 107F Effective: 7/1/71

Page: 3 of 3

Supersedes: 4/14/69

CLASS AAA CLEANLINESS REQUIREMENTS

- D. Filter (millipore) test must indicate:
 - 1. Only mild discoloration of the filter.
 - 2. Particulate contamination within the limits specified in E below.
- E. Particle population per square foot of surface tested must conform to the limits listed below. (A 100ml. approximately 3.5 cz. sample of flush solution may be considered as representing the rinse of one square foot of enclosed surface). Contamination per square foot is limited to:
 - 1. No particle greater than 500 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
 - 2. Not more than 25 particles between 175 and 500 microns.
 - 3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

VI. RELATED FORMS

- A. Record of an inspection will be listed on Form 1086, or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.
- B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to components of

cryogenic equipment. (Petyped 9/22/72 sba)



QUALITY CONTROL LAYOUT

Number: QCL 114F Effective: 7/1/71 Page: 1 of 2

Page: 1 01 2 Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS B CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class B.

II. SCOPE

These requirements normally apply to surfaces which thru use will not contact liquid air, oxygen enriched atmosphere or product fluids. Examples are: surfaces in air, refrigeration or similar circuits.

III. GENERAL

- A. Solvents used for cleaning shall be of commercially approved grade and/ or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.
- B. Cleaned systems shall be drained and thoroughly purged of cleaning media.
- C. Flux residue shall be removed from brazed and soldered connections of assemblies.
- D. Pressure test of assemblies, if performed after cleaning, may be accomplished with tap water (fit for drinking) or shop air. Systems tested hydrostatically shall be throughly dried.

IV. QUALITY REQUIREMENTS

Visual inspection of the direct surface under bright white light shall indicate:

- 1. No evidence of moisture.
- 2. No accumulation of rust, scale or other foreign matter.



QUALITY CONTROL LAYOUT

Number : Effective :

QCL 114F 7/1/71

Page:

Supersedes:

2 of 2 4/14/69

REQUIREMENTS FOR VENDOR CLASS B CLEANING

3. Free of easily visible films or concentrations of organic materials such as oil, grease, paint or similar materials.

V. SEALING

Cleaned surfaces shall have sufficient protection to maintain established cleanliness.

Number: QCL 115F Effective: 7/1/71

Page: 1 of 2

Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS A CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class A.

II. SCOPE

These requirements apply to surfaces which thru use contact fluid other than pure oxygen. Examples are: argon, liquid air, crude oxygen, hydrogen, nitrogen, etc.

III. GENERAL

- A. Solvents used for cleaning shall be of commercially approved grade and/ or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.
- B. Cleaned systems shall be drained and thoroughly purged of cleaning media.
- C. Flux residue shall be removed from brazed and soldered connections of assemblies.
- D. Pressure test of assemblies, if performed after cleaning, will be accomplished with water (fit for drinking), or dry, oil-free air or nitrogen.

 Systems tested hydrostatically shall be thoroughly dried.

IV. QUALITY REQUIREMENTS

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Free of loose (or potentially loose) rust, scale or other foreign matter.

Number: 6

QCL 115F 7/1/71

Page:

2 of 2

Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS A CLEANING

- 3. Free of slag and weld spatter.
- 4. Essentially free of organic material, such as oil, grease, crayon, paint, etc.
- B. Ultraviolet (3660 a.u. wavelength) examination shall show the surface:
 - 1. Essentially free of fluorescence. Isolated particles of lint and small areas of low intensity fluorescence are acceptable.*
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media except that which is due to oxidation of the parent metal.
 - 2. No evidence of oily residue.
- D. Particle population per square foot of surface tested is limited to:
 - No particle larger than 1500 microns (approx. 1/16 inch). A
 particle is defined as any solid matter other than a fiber. The
 size is determined by the longest single dimension.
 - 2. Not more than ten particles between 750 and 1500 microns.
 - 3. No fiber in excess of 6000 microns (approx. 1/4 inch), and no accumulation of fibers. A fiber is defined as a non-metallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

V. SEALING

The cleaned surface of components shall be protected against contamination by use of inert, vapor free, greaseless barrier materials.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleaned to Class A.'
*Typing error corrected 5/10/72 (Retyped 9/22/72 cmw)

ORM 6520

Number: QCL 116F Effective: 7/1/71

Page: 1 of 2 Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS AA CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class AA.

II. SCOPE

These requirements apply to fixed surfaces which thru use contact pure oxygen.

III. GENERAL

- A. Solvents used for cleaning shall be of commercially approved grade and/ or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.
- B. Cleaned systems shall be drained and thoroughly purged of cleaning media.
- C. Flux residue shall be removed from brazed, soldered and welded joints of assemblies.
- D. Pressure test of assemblies, if performed after cleaning, will be accomplished with filtered (as necessary to maintain required cleanliness) water, nitrogen, or dry, oil-free air. Systems tested hydrostatically shall be thoroughly dried.

IV. QUALITY REQUIREMENTS

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Essentially free of corrosion products.
 - 3. Free of scale, weld spatter and other foreign matter.
 - 4. Free of organic material such as oil, grease, crayon, paint, etc.
- B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:

Number:

QCL 116F

Effective:

7/1/71

Page : Supersedes :

2 of 2 4/14/69

REQUIREMENTS FOR VENDOR CLASS AA CLEANING

1. No hydrocarbon fluorescence.

- 2. Isolated particles of lint are acceptable.
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media.
 - 2. No evidence of oily residue (not detectable by A or B above).
- D. Particle population per square foot of surface tested is limited to:
 - No particle larger than 1000 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
 - 2. Not more than ten particles between 500 and 1000 microns.
 - 3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a non-metallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

V. SEALING

The cleaned surface of components shall be protected against moisture or contamination with suitable inert, vapor-free, greaseless barrier material.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleaned to Class AA'.

Number: **QCL 117F** Effective: 7/1/71

Page: 1 of 3 4/14/69

Supersedes:

REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class AAA.

SCOPE II.

These requirements apply to components with movable parts which thru use contact liquid or gaseous oxygen. Valves in pure product circuits other than oxygen, and in by-product (argon and others) circuits included.

III. GENERAL

- A. Solvents used for cleaning shall be of commercially approved grade and/ or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.
- B. Cleaned systems shall be drained and thoroughly purged of cleaning media.
- C. Flux residue shall be removed from brazed, soldered and welded joints of assemblies.
- D. Pressure test of assemblies, if performed after cleaning, will be accomplished with filtered (as necessary to maintain required cleanliness) water, nitrogen, or dry, oil-free air. Systems tested hydrostatically shall be thoroughly dried.

QUALITY REQUIREMENTS IV.

- A. Visual examination of the direct surface under strong white light shall indicate:
 - 1. No evidence of moisture.
 - 2. Free of corrosion, scale, slag, weld spatter and other foreign matter.

Number: QCL 117F Effective: 7/1/71

Page: 2 of 3 Supersedes: $\frac{1}{4}/1\frac{1}{1}/69$

REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

- Free of organic materials, such as oil, grease, crayon, paint, ink, etc.
- B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:
 - 1. No hydrocarbon fluorescence.
 - Complete removal of lint. If present, use nitrogen or dry, oilfree air for removal.
- C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:
 - 1. No appreciable discoloration of the wiping media.
 - 2. No evidence of oily residue (not detectable by A or B above).
- D. Filter (millipore) test must indicate:
 - 1. Only mild discoloration of the filter membrane.
 - 2. Particulate contamination within the limits specified in E below.
- E. Particle population per square foot of surface tested is limited to:
 - No particle greater than 500 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
 - 2. Not more than twenty-five particles between 175 and 500 microns.
 - 3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

Number: QCL 117F

Effective: 7/1/71

Page: 3 of 3Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

V. SEALING

The cleaned surface of components shall be protected against moisture or contamination with nondeteriorating, inert, vapor-free, greaseless barrier material. Wood and paper barriers are not acceptable.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleaned to Class AAA'.

Number: QCL 119F Effective: 7/1/71

Page: 1 of 3

Supersedes: 4/14/69

BRAZED ALUMINUM HEAT EXCHANGER

CLEANING REQUIREMENTS

I. PURPOSE

This standard lists the controls and defines the acceptance criteria for insuring cleanliness of brazed aluminum heat exchangers as specified in APCI purchase order.

II. QUALITY CHECK POINTS

- A. Cleanliness of raw materials.
- B. In-process braze of assembly.
- C. Periodic cleaning of braze bath.
- D. Wash and rinse of assembly.
- E. Test for cleanliness of streams.
- F. Quality tests of assembly.

III. PROCEDURE

- A. Core construction materials will be cleaned of hydrocarbon contamination before core stacking.
- B. Braze operations will be controlled to minimize dragout of the braze bath materials.
- C. Periodic cleanout of the braze bath will be performed to control the buildup of sludge.
- D. Wash and rinse solutions, and their length of application, will be controlled by standard vendor procedure to assure conformance to limits of halide count and surface neutrality.
- E. Each stream of a core shall be determined acceptable by testing a water flush sample.
 - 1. Halide count (after correction for blank) must not exceed 5 ppm.

Number: QCL 119F Effective: 7/1/71

Page: 2 of 3 Supersedes: 4/14/69

BRAZED ALUMINUM HLAT EXCHANGER

CLEANING REQUIREMENTS

- 2. pH value must be between 6.0 and 8.0.
- 3. A millipore filtered sample shall contain not more than 2 mg of solid residue per 100 ml of water sample. Filtration is required only when a visual examination of a sample indicates questionable quantity of solid residue.
- F. The port faces of oxygen streams will be cleaned of aluminum oxide and other braze residue. Core attachment surfaces, which thru use will contact product fluid, will be cleaned of hydrocarbon contamination. Examination of accessible surface with ultraviolet (3200 to 4000 angstrom unit long-wave filter) shall indicate:
 - 1. No evidence of fluorescence due to petroleum type hydrocarbons.
 - Mild reflection due to insignificant amount of aluminum oxide residue, or fluorescence due to isolated particles of lint, is acceptable.
- G. Cleaned surfaces of assemblies will, during additional fabrication, be maintained at a cleanliness level equal to the in-process checks.
- H. Hydrostatic tests will be made with clean, potable water.
- I. Drying will be accomplished in such a manner that will maintain cleanliness.
- J. Pneumatic tests will be performed with dry, oil-free air or nitrogen.
- K. Bubble type leak detection fluids, if used, will be thoroughly rinsed from surfaces of the assembly.
- L. All openings of assemblies will be sealed for shipment to prevent entry of water or contamination. Seal requires:

Number: QCL 119F

Effective: 7/1/71

Page: 3 of 3Supersedes: 4/14/69

BRAZED ALUMINUM HEAT EXCHANGER

CLEANING REQUIREMENTS

1. A vapor-free, inert nondeteriorating, greaseless barrier material.

2. Wood and paper barriers are not acceptable.

Number :

QCL 120F

Effective : Page :

7/1/71 1 of 3

Supersedes:

NEW

REQUIREMENTS FOR IPD SPECIFIED PAINT SYSTEMS

I. PURPOSE

To list requirements of paint systems specified and applied by Air Froducts manufacturing facilities.

II. PESPONSIBILITY

- A. IPD Engineering is responsible to specify conformance to this QCL. Other paint systems, specified by Project or Design Engineering will take preference over the requirements of this QCL.
- B. Quality Control is responsible to determine conformance to engineering specification.

III. PROCEDURE

- A. Inspection acceptance is required after each of the following:
 - 1. Surface preparation.

thorough power tool cleaning.

- 2. Prime cost
- 3. Finish coat.
- B. Acceptance will be determined by conformance to the following:
 - 1. The <u>surface</u> shall be cleaned to a Commercial Finish (see SSPC-SPE, Vis.1).

 This is a surface from which all grease, oil, dirt, mill scale, rust,

 paint and other foreign matter not imbedded in pits has been removed

 except for light streaks or discolorations. At least two-thirds of
 each square foot of surface shall appear a uniform gray-white, free

 of all visible residues, and the remainder shall be limited to the
 slight discolorations, staining, and slight residues described above.

 Manual cleaning, if necessary, must, as a minimum, meet the requirements
 of Grade C St 3 depicted in Vis. 1. This is described as a very

Number: QCL 120F Effective: 7/1/71

Page: 2 of 3 Supersedes: NEW

REQUIREMENTS FOR IPD SPECIFIED PAINT SYSTEMS

2. Undercoat will require:

- a. Use of a WASH PRIMER as a pretreatment for aluminum, stainless steel and copper.
 - (1.) Material shall conform to MIL-C-15328, and be used as directed by the manufacturer.
 - (2.) Dry film thickness must be 0.3 to 0.5 mil.
- b. Use of an IRON OXIDE PRIMER for untreated surface, or as addition to a pretreated surface described above.
 - (1.) Material shall conform to TT-P-636, and be used as directed by the manufacturer.
 - (2.) Dry film thickness must be 3.0 mil, minimum.
- 3. Topcoat will require:
 - a. Use of an ENAMEL material.
 - (1.) Material shall conform to MIL-E-489, and be used as directed by the manufacturer.
 - (2.) The total dry film thickness of the entire paint system must be 6.0 mil, minimum.
- C. The following adhesion test will be used, after a 24 hour minimum drying period, to establish quality assurance.
 - 1. Press a two inch length of a longer piece of 3/4" wide water resistant pressure sensitive tape onto the painted surface. Rub out all air bubbles under the pressed on section of tape.

Number: QCL 120F

Effective: 7/1/71

Page: 3 of 3

Supersedes: NEW

REQUIREMENTS FOR IPD SPECIFIED PAINT SYSTEMS

a. Apply tape to various painted locations such as corners, radii, welded seams, etc. The number of samples will be determined by the size and construction of the item, as well as visual interpretation of the quality of the paint system.

- 2. Allow sufficient time for temperature stabilization of the test section of tape.
- 3. Grasp the free end of tape and at a rapid rate strip the tape from the surface by pulling it back upon itself so that the tape is folded back to back during removal. Disregard flecks of paint on the tape if the removal of paint has not been completely through to the prime coat or the base metal to the following degree:
 - a. Any one spot exceed $1/\delta$ " average diameter, or more than one spot exceeding 1/16", or more than but less than 1/8", or more than five spots which are smaller than 1/16" average diameter.
- D. After a 72 hour minimum drying period, it should be difficult to separate the finish coat from the prime coat by either a sharp knife or by scraping with the fingernail.

				DATE:	January 24, 1963	
TO:	J.	М.	Norwood	SUBJECT:	Storage Tank Cleaning	,
FROM:	н.	н.	Master - Operations	Ref	erence: Your Memo of 1	2-14-62

W. L. Ball cc:

W. M. Say

R. G. Checksfield H. E. Wynn

M. H. Halsted

R. Ray

W. T. Rector

Our Operations Safety Manual states, "Production storage tanks are to be cleaned every two years unless experience indicates otherwise." We have been checking what histories we have and at present we have only four on record:

- Aliquippa (8/13/59) Dust removed from tank which had 2.8% by weight of lubricant which ignited in oxygen at 5980F. 3# dust from tank "A" and 12# from "B". Small globules of oil outlined at the liquid level. Tank was in service about 12 years.
- Santa Susana (1/60) In service about three years. Five gallons of dust removed but no definite trace of hydrocarbons.

- Cleaned sometime prior to May 1960. Edwards

West Palm Beach (3/60) - About two years in service. Fluorescence under black light in form of rings at liquid levels. Three pints of dust removed. Black dust residue on all surfaces.

West Palm Beach (7/61) - 3491.7 grams (7.7#) of solids containing 41.05 grams (.1#) 080.1.

Since our histories and analysis are limited, it is necessary we obtain more information so we can make a firmer ruling. It is recommended the following steps be taken in this regard:

- Since DuPont is questioning our policies, we should schedule a cleaning in this area. This could possibly be coordinated with the plant renovations so there would be no special down time.
- 2. The West Coast has tanks which are probably in service longer than most within the company. We should negotiate with government people to do this work at a plant which has a tank that has never been washed and could be scheduled where additional tanks could handle the storage while the work is being done. Via copy of this memo, I am requesting West Coast action or comments on the above.

If there have been other tank washouts which were done on any plants in any region, I would appreciate this information and any data connected with it.

Air Products and Chemicals, Inc.

PUT IT IN WRITING

TO: R. S. Ray DATE: March 11, 1964

FROM: A. L. Hatley SUBJECT: Cleaning LOX Storage Tank

No. 6 - Santa Susana

cc: L. Ball
H. Masters
E. Sherry

During the week of February 7, 1964, subject LOX tank was cleaned by Mel Thompson preparatory to installation of new nozzles. Since the Operations Safety Manual indicates the schedule for tank cleaning should be dependent upon experience the following information is submitted for determination of the cleaning frequency:

Surfaces of the tank were very clean with no traces of oil or other hydrocarbons. However, approximately 6 lbs. of extremely fine silica gel was removed from the tank. This silica gel was analyzed by Smith-Emery Company (report attached) by extraction with carbon tetrachloride and analysis on a Perkin Elmer 21 infrared analyzer. Results indicate 0.6% by weight hydrocarbons expressed as hexane. This calculates to 0.04 lbs. of hydrocarbons in the tank. Discussion with the analyst at Smith-Emery, Mr. Hughes, indicates that the spectrum is that of a straight chain hydrocarbon. We would presume that the hydrocarbon is the expander lubricant or cracked fractions from the expander lubricant, which are strongly adsorbed in the silica gel and carried by the gel into the storage tanks. We do not have clear records as to the last time this tank was cleaned, but would estimate that it was cleaned at least once in its past seven year history (approximately four years ago).

We request the determination of Mr. Ball as to whether these results would indicate a specific cleaning frequency for the 75 T/D LOX tanks and if so, what frequency should be used.

Enclosed with copy of this memo Mssrs. Ball and Masters, are samples of the dust recovered from the tanks.

OMICINAL SIGNED BY

A. L. Hatley

ALH:pc

Attachment

CHEMISTS . TESTING . INSPECTION . ENGINEERS

781 EAST WASHINGTON BOULEVARD LOS ANGELES 21, CALIFORNIA

ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS. PHYLOGIZATION FOR PUBLICATION OF OUR REPORTS, CONCLUSIONS, OR EX-TRACTS FROM OR RECARDING THEM IS RESERVED PENDING OUR WRITTEN APPROVAL AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC AND GURSELVES.

FILE NO.: 2285-64 LABORATORY NO.: 0-514972

DATE: FEBRUARY 17, 1964

AIR PRODUCTS & CHEMICAL CO. 23320 So. ALAMEDA

LONG BEACH, CALIFORNIA

"DUST FROM LOX TANK"

P.O. No. H34-35199

ATTN: JIM SOPH

REPORT OF DETERMINATION

IN ACCORDANCE WITH YOUR INSTRUCTIONS THE SAMPLE OF DUST SUBMITTED BY YOU WAS TESTED AND WE REPORT AS FOLLOWS:

HYDROCARBONS, PERCENT BY WEIGHT AS HEXANE ----- 0.6

RESPECTFULLY SUBMITTED, SMITH-EMERY COMPANY



PUT IT IN WRITING

				DATE	June 26, 1970	
To	W. L. Ba	all	Subject	LOX Tank	(S	
From	н. н. ма	aster - Operations				

cc: M. H. Halsted

C. McKinley

W. J. Scharle

H. E. Wynn

You had requested I get whatever information I could to help you in some determination of cleanliness of our storage tanks. Work has been very limited in this area but the following are from the writer's experience, discussions with M. Thompson, and a report from New Johnsonville.

M. Thompson stated that most, if not all, tanks at Santa Susana and Nimbus were entered and inspected at one time or another. Average time in service at the inspections was 3 to 4 years. There was no noticeable visible contamination and the tanks were inspected with a black light. A white lintless rag was to be used to wipe any contamination but he could not recall any real need for it although it might have been used on a few doubtful areas. In one case at Nimbus, there were some metal stains, believed from manufacture, which were cleaned with a wire brush.

The writer was in one of the Santa Susana spherical tanks about a year and a half ago when I happened to be there while they were investigating an inner shell leak. There was no indication of contamination excepting very minute amounts of sandy material, probably silica gel, in the bottom of the tank. M. Thompson says they observed nothing worse than this during their repair period.

In July 1963 the New Johnsonville LOX tank was entered and hosed down with solvent. The tank had been in service 40 months. Analysis of the solvents used indicated a total of 2.125 grams which averaged out on the complete tank surface would have been about .7 miligrams per square foot. I also requested they clean one square foot of what appeared to be the worse area with a clean rag, rinse the rag in solvent, and submit the solvent for analysis. Analysis indicated 6 miligrams in this area. The right (north) side of the tank had a "bath tub ring." The left side had very little deposit excepting at one end. The worst portion of the "ring" was on the side toward the LIN tank (it is an insulated building with two separate storage tanks parallel to each other). The area near the suction line to the pump had about 8 tablespoons of dust and a gummy deposit which was not identified. As I recall, I submitted samples of this material to R&D but it was lost somewhere.

ORIGINA	LS	IGNED BY
н.	Н.	Master

HHM:1c



PUT IT IN WRITING

		DateJuly 9, 1964
To	J. J. Mittleman	Subject Washout Analysis of Sun Oil Company's
From	F. K. Kitson	LOX Tank Vaporizer

cc: B. Berrettini

W. L. Ent

H. H. Master

As discussed with L. Ball the washout information on the subject storage tank vaporizer will be transmitted to the customer by the I&M Department. The solvent washout analysis was reported on Analytical Lab Report No. 64-225 and 224 dated July 16, 1964 showing a total of .1056 grams of hydrocarbon contamination. The I-R identification of the contamination was aliphatic hydrocarbons. The quantity of LOX put through the vaporizer has been determined as 542,486 SCF of oxygen from January 1963 through the end of April 1964.

On May 5, 1964, 24.25 gallons of solvent, inhibited methylene chloride, was introduced into the main internal vaporizer and recirculated for approximately ten minutes with a 9 GPM pump. 23.42 gallons of solvent were recovered and a representative sample obtained. The total contamination mentioned above was calculated on the basis of solvent introduced and the residual hydrocarbons in the solvent "blank" were deducted.

The contamination accumulating in the vaporizer is negligible as was to be expected based on the limited washouts of several other LOX storage tank vaporizers.

As there are vaporizers which have been operating for a considerable number of years it was recommended that a vaporizer with the most service be solvent washed (see memo L. Ball to J. Mittleman dated 3-3-64). Please advise if plans have been made to accomplish this.

)

ORIGIN	AL	SIGNED	вү
 F.	к.	Kitson	

FKK/jmf

B. Berrettini (3)

H. Linde

H. Master

G. E. Schmauch



ANALYTICAL REPORT

DATE: 6/16/64

LAB. NO.: 64-223 & 224

SAMPLE OF:

Solvent washouts

FROM:

Sun Oil Co., Delaware City

SAMPLING DATE:

REQUESTED BY:

H. Master

SAMPLED BY:

ANALYSIS REQUESTED: Oil content and infrared identification.

ANALYTICAL METHOD: Solvent extraction

ANALYST: S.R.M.

IWO NO.: 54-0030

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

LAB NO.	SAMPLE	OIL CONTENT BY WEIGHT	SOLVENT GAL.IN	USED GAL.OUT	INFRARED IDENT
64=223	Reference for 64-224	0.02740	24.25		***
64-224	Internal vaporizer on 600 gal. Ryan Tank (Oxygen Service)	0.00115*	24.25	23.42	Aliphatic hydrocarbons

^{*}Blank Correction has been made



Pennsalt Corporation, "Cleaning of Liquified-Gas Processing Equipment, Pennsalt Technical Bulletin, 6 pages, dated February 3, 1960.

Air Products and Chemicals, Inc.

PUT IT IN WRITING

TO: Distribution DATE: August 5, 1963

FROM: F. K. Kitson SUBJECT: Cleaning for Oxygen Service

cc: R. Baker

W. L. Ball

J. L. Cost

H. F. Mason

C. McKinley

C. J. Schilling

It has been recognized that an inconsistency regarding the cleaning requirements of material for oxygen service exists within different groups of the company. The specific areas where cleaning requirements and acceptance levels are not established are:

- 1. Materials purchased for installation at a construction site requiring field cleaning.
- 2. Repairs and modifications to existing systems at Operations and I&M facilities.
- 3. Possibly some of the affiliated companies.

The only reference within the company that has clearly defined the acceptance levels for materials cleaned for oxygen service is contained in QCL's 104F through 107F and 114F through 117F (for vendors' use). As groups within the company think the acceptance criteria contained in these QCL's is too stringent and costly, a review of the few references on the subject available in our files has been made and is shown in Attachment 1. It should be noted that the stringent controls contained in these criteria are probably due to the failure of missile systems when small particles obstructed jet and orifice openings presenting mechanical rather than safety problems. Thus, it is reasonable to expect that criteria for the commercial industry would not need to be as stringent as existing Military specs. LOX produced by commercial plants and utilized by the Military for missile propellent systems is filtered during transfer to remove particles well below the maximum sizes listed in Attachment 1.

It is thought that from a safety consideration the acceptance criteria listed in the above mentioned QCL's can be relaxed, particularly the maximum permissible particle size. Considerations other than safety must be evaluated such as specifications contained in customer contracts, the Military in particular. It would seem advisable that the company should adopt an acceptance level for oxygen cleaned material that applies to all groups within APCI and the affiliated companies. To make this information available to each location Safety Standard 608.1 "Inspection of Materials for Oxygen Service," redraft August 5, 1963 has been prepared and is transmitted as Attachment 2 for the Distribution's review. The acceptance of the criteria based on safety considerations in the standard would necessitate a revision to the applicable QCL's.

Comments from the recipients of this memo at their earliest convenience would be appreciated.

ORIGINAL SIGNED BY.
F. K. Kitson

FKK/jmf

Encl.

A. Proposed Military Specification Draft dated April 17, 1961

Permissible contamination limits (airborne and fixed components)

1. Total solid and fibrous particles -

25 mg/liter effluent or
25 ppm by weight

2. Solid particles -

350-500 micron size - 20 per liter of effluent or 4 per sq. ft. of area greater than 500 microns - none

3. Fibrous particles -

175-300 micron diameter and 1000-2000 micron length - 10 per liter of effluent or 2 per sq. ft. of area

greater than 350 micron diameter and 2000 micron length - none

B. Manufacturers of Rocket Propulsion Systems

1. Particles -

Longest dimension -

0-300 micron - no limit by count 300-500 micron - five per 100 ml of liquid 500-1000 micron - one per 100 ml of liquid over 1000 micron - none

- 2. Fibers -
 - 25 micron diameter by 750 micron length no limit by count
 - 25 micron diameter by 750-2000 micron length twenty per 100 ml of liquid
 - 40 micron diameter by 2000-6000 micron length two per 100 ml of liquid

over 6000 micron length - none

SAFETY STANDARD

608.1

608 Cleaning and Inspection of Materials Inspection of Materials for Oxygen Service

1. PURPOSE

This standard lists classifications of cleaning required for equipment in oxygen service and discusses the various methods used in establishing acceptance of materials for oxygen service. The standard is issued to inform all personnel of the existing methods of inspecting material for acceptability for oxygen service and establish acceptance criteria. It is not the intent of this standard to determine when material shall be inspected, but to provide information such that the responsible personnel can evaluate the necessity for inspection and the means to accomplish this inspection.

2. SCOPE

This standard shall be used at all Air Products and affiliates producing and distribution locations, equipment fabricating facilities, and air separation plant construction sites in determining the acceptability of material for oxygen service where specific inspection procedures and acceptance criteria is not available.

3. DETERMINATION OF ACCEPTABLE CLEANING LEVELS

The problem of determining the required cleanliness and establishing acceptance levels of equipment, piping, etc. for oxygen service, liquid or gaseous, has existed for many years within the industry. An attempt to

resolve this problem has been made by establishing classifications of cleaning based on the intended service and is outlined below illustrating the cleanliness requirements of equipment, piping, and valves for an air separation plant. (A listing of components and the required cleaning classification may be found in QCL 101F.)

- A. Any surface which will contact, through normal use, a pure or enriched oxygen atmosphere shall be free of all loose or potentially loose slag, scale, metallic chips, or any other foreign materials as shown in the following subsections.
 - (1) Class AAA Cleaning. Class AAA is the most stringent standard cleaning classification. It is applied to equipment with moving parts such as compressors, expanders, pumps, valves, etc. which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AAA cleaning is as follows:
 - a. Bright White Light Inspection

 Surfaces inspected shall be free of all residue, discoloration

 (other than that which is due to the metal), particles having

 a diameter larger than 500 microns and fibers having a diameter

 greater than 200 microns or a length greater than 0.5 inch.

 The surface shall also be free of any excessive concentration

 of smaller particles or fibers detectable with the naked eye.
 - b. Wipe Test
 Surface areas shall be wiped with clean white filter paper and the filter paper inspected to insure the absence of residue, discoloration, and fibers as covered in item 1.

- c. Black Light Inspection
 - Surfaces inspected shall be free of any fluorescence other than isolated spots of lint and dust detectable by black light.
- (2) Class AA Cleaning. Class AA is the more commonly used standard cleaning classification which is applied to stationary parts which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AA Cleaning is as in Class AAA with the exception of the maximum diameter particle size permitted which is 1000 microns.
- (3) Class A Cleaning. Class A is the most relaxed standard cleaning classification applied to equipment which will, through use, contact an oxygen rich atmosphere. Acceptance criteria for Class A cleaning is as follows:
 - a. Bright White Light Inspection

 Surfaces inspected shall be free of visible hydrocarbons, all

 particles having a diameter of greater than .125 and fibers

 having a length greater than .75 inch.
 - b. Black Light Inspection
 Surfaces inspected shall not exceed a fluoresce of a low intensity
 on 25 per cent of the surfaces inspected. Highly fluorescent
 specks shall not exceed .125 inch in diameter.
- B. The standard cleaning classification which is applied to equipment which will not contact an oxygen enriched atmosphere is Class B. Acceptance criteria for Class B cleaning is as follows:
 - (1) Surfaces shall be free of all excessive loose or potentially loose metallic chips, scale, slag or other foreign particles greater than .125 inch in diameter.

}

(2) Surfaces inspected shall be free of excessive grease, oil, or other hydrocarbons.

4. METHODS OF INSPECTION

The various methods utilized in determining acceptability of surfaces exposed to oxygen service and specified above are discussed below with the limitations.

- A. Inspection of Particulate Matter
 - Accessible surfaces shall be inspected for particulate matter using adequate lighting with the naked eye, the aid of a pocket magnifying glass (preferably calibrated) or other means. The limit of detection of the average naked eye (20/20 vision) is approximately 40 microns. Five hundred microns is the approximate diameter of the shaft of a straight pin; 1000 microns is approximately the diameter of a common paper clip.
- B. Black Light Inspection

Accessible surfaces shall be inspected for hydrocarbons which fluoresce with a long wave black light of approximately 3600 Angstroms. (See Table 1 for a partial listing of hydrocarbon lubricants and coolants that fluoresce.) It is important to recognize that many hydrocarbons do not fluoresce and that others might fluoresce only because a fluorescent material has been added by the manufacturer. The removal of this fluorescent additive, such as might occur at elevated temperatures experienced in a compressor, could result in loss of fluorescence. Conversely, all materials that fluoresce are not hydrocarbons, such as certain solder fluxes and Oakite residues.

Surfaces inaccessible to inspection with the eye or a boroescope may be inspected by comparing new unused solvent and the effluent solvent rinse under a black light and bright white light. Any increase in

discoloration in the solvent rinse shall be cause for rejection. It must be recognized that this method is the least positive method and may be used as a last resort being fully aware of its limitations. It is preferable to obtain a sample of the rinse and have an analysis performed to detect hydrocarbons (see Section E).

C. Bright White Light

Accessible surfaces shall be visually inspected with a bright white light for discoloration which could be an indication of hydrocarbons which do not fluoresce (experimental work is cited in Table 2 as a guide). Discoloration which is determined to be an integral part of the metal is acceptable. The bright white light may also be used as an aid in the particulate matter inspection and the wipe test.

D. Wipe Test

Accessible surfaces shall be wiped with clean white filter paper on two representative areas for an indication of hydrocarbons. Discoloration other than from oxidation of the metal and fluoresce is not permitted on any portion of the filter paper that was in contact with the surface being cleaned.

E. Solvent Rinse Analysis

The most positive inspection procedure for the determination of material being free of hydrocarbons is an analysis of the solvent rinse although this method is impractical for the majority of applications. This should be accomplished by obtaining a representative sample in a metal container which has been thoroughly washed in solvent and is free of any hydrocarbon seals (rubber, paraffin impregnated seals, etc.) in the lid. The quantity of solvent introduced and recovered should accompany the sample with a

solvent "blank" (clean unused solvent) to R&D for analysis.

NOTE: Additional information is available in the Analytical Testing Standards
Manual, Section 675.12.01, Analytical Test.

FKKitson/jmf

*			

Table 1

The following lubricants, coolants, and solvents are listed as a guide in categories according to the fluorescing properties.

	essor <u>Lubricants</u> (as manufa	ctured)
(also	reciprocating expanders)	
	Mobil Kote 501	Bright
	Mobil 105	Bright
	Mobil 103	Bright
	Mobil Heavy	Bright
	Mobil Medium Heavy	Bright
	Mobil Light	Bright
	Havoline #40	Bright
	Havoline #30	Bright
	Solnus 500	Bright
	Solnus 300	Bright
	Ucon 50 HB 55	Bright
	Ucon 50 HB 280	Bright
	Ucon 50 HB 170	Medium
	Ucon 50 HB 660	Medium
	Cellulube 220	Medium
	Cellulube 300	Medium
	Cellulube 550	Medium
Refr	igeration System Lubricant	
	Capella	Bright
	Sunisco 3G	Bright
Turb	o Expander Lubricant	
	Gulf Paramount 39	Bright
	Texaco Paramount	Bright
Cool	ants	
	Cuprol B-6	Medium
Solv	ents	
	Paco	Medium
	Methylene Chloride	Very slight
	Trichloroethylene	Very slight
Othe	rs	
	RP-1 (rocket propellent) -	ydrocarbons (hexane, etc.) - no fluorescence - No Fluorescence - No Fluorescence
	•	

Experimental work by R&D gave the following results:

Surface of test material - polished aluminum Type hydrocarbon applied - (1) N-hexadecane

Film thickness - 500 mg/ft

Appearance under bright white light - definite oily film.
Finger smear test - a definite smear pattern was observed.

This smear pattern was approximately 50 per cent obscured by film flow within five minutes.

The results of the above tests were identical for both hydrocarbons tested.

NOTE: In using this information as a guide, two points which must be considered are:

- 1. The hydrocarbons utilized in the test were new and unused. Hydrocarbons in existing systems will not be in this condition and detection would probably be more difficult.
- 2. The polished aluminum surface would permit detection of hydrocarbons more readily than irregular surfaces such as in steel pipe or vessels.

Air Products and Chomicals

PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 1 OF 7

DATE 4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

This Procedure is Identical with Section 608.1 Safety Standards

I. PURPOSE

To establish a standard procedure that will 1) present the various cleaning classifications, with acceptance criteria, for equipment and material used in air plants and oxygen service; 2) present a summary of existing methods for inspecting such material; and 3) thereby provide responsible Operations personnel with helpful information in their attempt to evaluate both the necessity for inspecting such material and the best way to accomplish the inspection.

Note: It is not the intent of this procedure to determine when material shall be inspected.

II. RESPONSIBILITY

Plant Managers and Maintenance Superintendents are responsible for the proper use of the material contained in this procedure.

III. PROCEDURE

A. Scope

This procedure shall be used at all Air Products and Chemicals, Inc. producing and distribution sites, and at air separation plant sites in determining the acceptability of material for oxygen service.

B. QCL (Quality Control Layout) Procedures

Attachment 1 lists required cleaning standards for air plant circuits and components. QCL 103 F, also attached, lists approved cleaning agents and associated equipment and supplies. QCL's 104 F through 107 F list detailed procedures for cleanliness and also list inspection criteria for testing various air plant circuits and components. QCL's 114 F through 117 F, submitted to vendors and normally processed by Purchasing personnel, are not included here. They correspond to the attached QCL's 104 F through 104 F.

C. Determination of Acceptable Cleaning

The following information shall be used to establish classifications of cleaning required based on intended service and to determine the cleanliness requirements of equipment, piping, and valves. Equipment for a pure product fluid other than oxygen (such as nitrogen) that may be converted to oxygen service shall be cleaned to the applicable classification for oxygen service.

FORM 3536 2767



PLANT OPERATIONS MANUAL

PAGE 2 OF 7

DATE 4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

- 1. Any surface which will contact, through normal use, a pure or enriched oxygen atmosphere shall be free of all loose (or potentially loose) slag, scale, metallic chips, or any other foreign materials as shown in the following subsections.
 - a. Class AAA Cleaning Class AAA is the most stringent standard cleaning classification. It is applied to equipment with moving parts such as reciprocating compressors, expanders, pumps, valves, etc., which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AAA cleaning is as follows:
 - (1) Bright White Light Inspection. Surfaces inspected shall be free of all moisture, residue, discoloration (other than that which is due to the metal), particles having a diameter larger than 500 microns, and fibers exceeding 2000 microns in length. The surface shall also be free of any excessive concentration of smaller particles or fibers detectable with the naked eye.
 - (2) Wipe Test. Surfaces shall be wiped with clean white filter paper and the filter paper inspected to insure the absence of oils not detectable by black light, residue, discoloration other than that which is due to the metal, particles, and fibers as covered in C,l,a,(1).
 - (3) Black Light Inspection. Surfaces inspected shall be free of any fluorescence other than isolated spots of lint and dust detectable by black light.
 - b. Class AA Cleaning Class AA is the more commonly used standard cleaning classification which is applied to stationary parts which will, through use, contact liquid or gaseous oxygen. Acceptance criteria for Class AA Cleaning is as in Class AAA with the exception of the maximum diameter particle size permitted, which is increased to 1000 microns.
 - c. Class A Cleaning Class A is the most relaxed standard cleaning classification applied to equipment which can contact a liquid air or an oxygen enriched atmosphere. Acceptance criteria for Class A cleaning is as follows:



PLANT OPERATIONS MANUAL

PAGE 3 OF 7

DATE 4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

- (1) Bright White Light Inspection. Surfaces inspected shall be free of visible hydrocarbons, all particles having a diameter greater than 1500 microns, and fibers having a length greater than 6000 microns.
- (2) Wipe Test. Surfaces shall be wiped with clean white filter paper and the filter paper inspected to insure the absence of residue and oils not detectable by black light.
- (3) Black Light Inspection. Surfaces inspected shall be essentially free of fluorescence. Isolated particles of fluorescent lint and a very low intensity fluorescence will be acceptable.
- 2. The standard cleaning classification which is applied to equipment which will not contact an oxygen enriched atmosphere is Class B. Acceptance criteria for Class B cleaning is as follows:
 - a. Surfaces shall be free of all accumulations of loose metallic chips, scale, slag, or other foreign particles.
 - b. Surfaces inspected shall be free of excessive grease, oil, or other hydrocarbons.

D. Methods of Inspection

The various methods used to determine acceptability of surfaces exposed to oxygen service and specified above are discussed below with the limitations.

1. Inspection of Particulate Matter

Accessible surfaces shall be inspected for particulate matter, using adequate lighting with the naked eye, the aid of a pocket magnifying glass (preferably calibrated) or other means. The limit of detection of the average naked eye (20/20 vision) is approximately 40 microns. 100 microns equal .004 inch; 500 microns is the approximate diameter of the shaft of a straight pin; 1000 microns is approximately the diameter of a common paper clip.

2. Black Light Inspection

Accessible burfaces shall be inspected for hydrocarbons which fluoresce with a long wave black light of approximately 3000 angstroms. (See



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

SECTION <u>1.08</u>

PAGE 4 OF 7

DATE 4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

table 1 for a partial listing of hydrocarbon lubricants and coolants that fluoresce.) It is important to recognize that many hydrocarbons do not fluoresce and that others might fluoresce only because a fluorescent material has been added by the manufacturer. The removal of this fluorescent additive, such as might occur at elevated temperatures experienced in a compressor, could result in loss of fluorescence. Conversely, all materials that fluoresce are not hydrocarbons, such as certain solder fluxes and Oakite residues.

Surfaces inaccessible to inspection with the eye or a borescope may be inspected by comparing new unused solvent and the effluent solvent rinse under a black light and bright white light. Any increase in discoloration in the solvent rinse shall be cause for rejection. It must be recognized that this method is the least positive method and may be used as a last resort, being fully aware of its limitations. It is preferable to obtain a sample of the rinse and have an analysis performed to detect hydrocarbons (see D5).

3. Bright White Light

Accessible surfaces shall be visually inspected with a bright white light for discoloration which could be an indication of hydrocarbons which do not fluoresce. Discoloration which is determined to be an integral part of the metal is acceptable. The bright white light may also be used as an aid in the particulate matter inspection and the wipe test.

4. Wipe Test

Accessible surfaces shall be wiped with clean white filter paper on two representative areas for an indication of hydrocarbons. Discoloration other than from oxidation of the metal and fluorescence is not permitted on any portion of the filter paper that was in contact with the surface being inspected.

5. Solvent Rinse Analysis

The most positive inspection procedure for determining whether or not materials are free of hydrocarbons is an analysis of the solvent rinse, although this method is impractical for most applications. Obtaining a representative sample in a metal container which has been thoroughly



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 5 OF 7

DATE 4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

washed in solvent and is free of any hydrocarbon seals (rubber, paraffin impregnated seals, etc.) in the lid. The quantity of solvent introduced and recovered should accompany the sample with a solvent "blank" (clean, unused solvent" to R & D for analysis.

TABLE I

The following lubricants, coolants, and solvents are listed as a guide in categories according to the fluorescing properties.

DESCRIPTION	PROPERTIES
Compressor and Reciprocating Expander Lubricants (as manufactured)	
Mobil Kote 501 Mobil DTE 105 Mobil DTE 103	Bright B r ight Bright
Mobil Heavy Mobil Medium Heavy Mobil Light	Bright Bright Bright
Texaco Regal A Texaco Regal AFB2 Texaco Regal B Texaco Regal PC Texaco Regal F Texaco Regal G Texaco Regal PE Havoline #40	Bright Bright Bright Bright Bright Bright Bright Bright
Havoline #30 Solnus 500 Solnus 300 Ucon 50 HB 55 Ucon 50 HB 280 Ucon 50 HB 170 Ucon 50 HB 660	Bright Bright Bright Bright Bright Medium Medium
Cellulube 220 Cellulube 300 Cellulube 550	Medium Medium Medium

Air Products and Chamicals

PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

SECTION _________ PAGE 6 OF 7

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

DECODIDATAN	TO OWED TO
DESCRIPTION	PROPERTIES
Oxygen Compatible Lubricants	
Florolube	Very Slight
Halocarbon Kel-F	Very Slight Very Slight
Refrigeration System Lubricant	
Capella Sunisco 3G	Bright Bright
Turbo Expander Lubricant	
Gulf Paramount 39	Bright
Texaco Regal A	Bright
Coolants	
Cuprol B-6	Medium
Solvents	
Paco	Medium
Methylene Chloride Trichlorethylene	Very Slight Very Slight
Others	
RF-1 (rocket propellant)	None
Nujol (mineral oil) Saturated straight chain	None
hydrocarbons (hexane, etc.)	Non e

IV. RELATED PROCEDURES

- 1.05 Plant Solvent Washout General

- 1.07 Byron-Jackson Oxygen Pump Washout
 1.09 Compatible Materials for Oxygen Service
 1.11 Safety Testing Schedule for Operations Plants
- 5.18 Safety Reports

Required Cleaning Levels (Attachment 1)

Air Products and Chamicals

PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE_7_OF_7_DATE_4/4/67

CLEANING AND INSPECTION FOR EQUIPMENT IN AIR PLANTS AND IN OXYGEN SERVICE

QCL 103 F Approved Cleaning Agents and Associated Equipment and Supplies
(Attachment 2)

QCL 104 F Class B Standard Cleaning Procedure (Attachment 3)

QCL 105 F Class A Standard Cleaning Procedure (Attachment 4)

QCL 106 F Class AA Standard Cleaning Procedure (Attachment 5)

QCL 107 F Class AAA Standard Cleaning Procedure (Attachment 6)

V. RELATED FORMS

	•	

REQUIRED CLEANING LEVELS

CIRCUIT AND COMPONENT

REQUIRED CLEANING

		Ve	endor Cleaned	117F	1 1 6F	115F	114F
			PCI Cleaned	107F	106F	105F	104F
		12	. 02 02001104	AAA	AA	A	В
1.	Air	Circuit					
_,		Air Drier					В
		Carbon Dioxide Adsorbers					В
		Caustic Purifiers					В
		Compressors					_
		1.4.1 Coolers					В
		1.4.2 Separators					В
		1.4.3 Surge Tanks					В
		1.4.4 Condensate Traps					В
	1.5	Condensate Traps					В
		Exchangers					
		1.6.1 Air Precoolers					В
		1.6.2 Freon-Air Exchangers					В
		1.6.3 Main Air Exchangers					В
	1.7	Expanders					
		1.7.1 Expander Oil Adsorbers					В
	1.8	Filters					
	,	1.8.1 Air Drier Filters					В
		1.8.2 Expander Oil Adsorber Filter	s				В
	1.9	Piping Upstream of Air Expansion Va.					В
	-	Regenerators					В
		Separators					В
		Valves up to the Air Expansion Valv	e				В
2.	Liqu	id Air Circuits					
	2.1	Piping Downstream of Air Expansion	Valve				
		up to the High-pressure Column				A	
	2.2	Receivers				Α	
	2.3	Valves Including Air Expansion Valv	re and up				
		to the High-pressure Column		AAA			
3.	Crud	e Oxygen or Oxygen Enriched Circuits	•				
	3.1	CO2 Filters and Adsorbers)			_	
		(Crade Oxygen Circuit)				Α	
	3.2	High-pressure Column Components and					
		Assembly				A	
	3.3	Hydrocarbon Adsorbers				A	
	3.4					A	
		Phase Separators				Α	
	3.6	Piping up to the Hydrocarbon					
		Adsorber Inlet				A	
	3.7	Valves up to the Hydrocarbon Adsorb		AAA			
	3.8	Piping Downstream of the Hydrocarbo	on			۸	
		Adsorbers				A	
	3.9	Valves Downstream of the Hydrocarbo	on	A A A			
		Adsorbers	. 3	AAA			
	3.10	Expanders Processing Oxygen Enriche	sa.		A -		
		Air			AA		

REQUIRED CLEANING LEVELS

CIRCUIT AND COMPONENT

REQUIRED CLEANING

CIR	COLL	AND COMPONENT					
			Vendor Cleaned	117F	116F	115F_	114F
			APCI Cleaned	107F	106F	105F	104F
				AAA	AA	A	В
4.	Liqu	id and Gaseous Oxygen Circuits			121		
		Column Components and Column Assem	ıb1v		AA		
		Charging Manifolds			AA		
		Compressors					
	4.3			AAA			
		4.3.1 Reciprocating		AAA			
		4.3.2 Centrifugal			AA		
		Expanders			AA		
	4.5	Instrumentation					
		4.5.1 Flowmeters (Turbine or					
		Displacement)		AAA			
		4.5.2 Rotameters		AAA			
		4.5.3 Others			AA		
	11 6	Phase Separators			AA		
		Pumps		AAA	•		
				ruut	AA		
		Piping			nn.		
	4.9	Reboiler Condensers			AA		
		4.9.1 Pot Type					
		4.9.2 Thermosiphon			AA		
	4.10	Storage Tanks (Inner Surface)			AA		
		4.10.1 Double Jacketed Tanks (Oute					
		Surface of Inner Tank and	i				
		Inner Surface of Outer Ta	ank-Particle				
		Size Requirements Waived)			A	
	4.11	Storage Tubes			AA		
		Subcoolers			AA		
		Valves (Check, Control, Hand and					
	ر ـــــ • ٠	Safety)		AAA			
	և դև	Vaporizers			AA		
		Vents				A	
	4.17	Venda					
_	MT : 4	ranan dinamita					
5.		rogen Circuits					
	2•∓	Reactivation Circuits	atimtian				
		5.1.1 Drier and Oil Adsorber Rea	CCIVACTOR				В
		Heater and Piping	5 . 4.2 4.2				
		5.1.2 CO2 and Hydrocarbon Adsorb	er Reactivation			A	
		Heater and Piping				A	
		Nitrogen Side of Reboiler Condens				A	
	5.3	Nitrogen Phase Separators and Pip	ing			_	
		Supplying Reflux to the Column				A	
	5.4	Subcoolers, Reflux Nitrogen				A	
		Other Piping					В
	,-,						
6.	De+	rost Circuits					
٠.		Heater				A	
	6.2	_	d to				
	0.2	Libing (circuits shourd be create	circuit				
		the cleanliness required by the	CIICUIU				
		to be defrosted.)					В
	6.3	Vent Stacks					_

REQUIRED CLEANING LEVELS

CIRCUIT AND COMPONENT

REQUIRED CLEANING

		Vendor Cleaned	117F	116F	115 F	114F
		APCI Cleaned	107F	106F	105F	104F
			AAA	AA	A	В
7.	By-products Circuits (Argon and Others)					
	7.1 Columns				Α	
	7.2 Condensers				Α	
	7.3 Piping				A	
	7.4 Separators				A	
	7.5 Valves		AAA			
8.	Pure Product Circuits (Other than Oxyge	en)				
	8.1 Instrumentation	•		AA		
	8.2 Charging Manifolds				Α	
	8.3 Piping				Α	
	8.4 Storage Tanks				A	
	8.5 Storage Tubes				Α	
	8.6 Pumps			AA		
	8.7 Vaporizers				A	
	8.8 Valves		AAA			
9.	Service Circuits					
•	9.1 Refrigeration					В
	9.2 Steam					В
	9.3 Water					В
	· -					

CLEANING FOR OXYGEN SERVICE

Ву

E. J. Bassler
Safety Department
Air Products, Incorporated
Allentown, Fennsylvania

January, 1960

TABLE OF CONTENTS

]	Page No.
Int	r odu	ction	1
I.	Cle	aning Agents	1
	A.	Chlorinated Solvents	2
	В.	Water Soluble Cleaning Solutions	7
	C.	"Freon" Solvents	9
	D.	Hazardous Solvents	10
II.	Cle	aning Methods	10
	Α.	Cold Cleaning	10
	В.	Vapor Degreasing	11
	C.	Detergent Cleaning	13
	D.	Ultrasonic Cleaning	13
Sel	ecti	on of Cleaning Methods	14
Ins	pect	ion	14
Bib.	liog	raphy	15

LIST OF TABLES

	Page	No.
Cleaning Solvents, Physical and Chemical Properties	3	
Effect of Solvents on Metals	5	
Solvent Manufacturers	17	

INTRODUCTION

Discussion of mutual problems by air plant producers and users at the Safety Conference sponsored by Air Products, Incorporated in July 1959 gave evidence of the need for education and standardization of methods for cleaning equipment to be used in oxygen service.

The necessity for maintaining high standards of cleanliness for equipment to be used in oxygen service has long been recognized by those people associated with oxygen systems. In the design of air plants, every effort is made to insure the minimum of contamination of equipment. Oil adsorbers, hydrocarbon adsorbers, sealing systems for lubricated machinery and drainage of oxygen streams are examples of designing for safety. However good the design is and no matter how well the oxygen plant is operated, there will still be small quantities of undesirable material which will contaminate the equipment. The accumulation of these contaminants must be controlled so that explosive limits are never reached.

It is necessary, therefore, to start with a clean plant and maintain this cleanliness by cleaning and degreasing the equipment to prevent accumulation of contaminants. Many methods can be used to clean the equipment; the selection depending on the type of soil to be removed, material of construction, size and shape of equipment, and whether or not the equipment can be removed from the oxygen generator.

The amount of contaminants will be different for each plant and for each piece of equipment as well. The data obtained from inspections will reveal the level of contamination and will determine the frequency of cleaning required. The cleaning schedule and cleaning methods to be used should be based upon inspections and experience for each plant.

I. CLEANING AGENTS

In the selection of cleaning agents consideration should be given to the following:

- 1. Type of soil to be removed.
- 2. Compatibility of the cleaning agent with the metal to be cleaned.
- 3. Hazards to personnel.
- 4. Cost.

There are many types of soil and each one is best cleaned by particular solvents. Some soils are soluble in water, others in acids or alkalies, and still others in organic solvents. Mineral soils may be either acid or alkali soluble; animal and vegetable fats are dissolved by alkalies or organic solvents; soils of petroleum oil or decomposed oil products are best dissolved by the organic solvents.

Soil as referred to in this paper represents any undesirable contamination. The nature of the contaminant may be liquid or solid, metallic or nonmetallic, or organic or inorganic. In the discussion of cleaning agents the best agent to be used for a particular soil is noted.

A. Chlorinated Solvents

Solvent cleaning has become one of the most widely used procedures for cleaning process equipment of all kinds. The development of nonflammable chlorinated hydrocarbons with properties which make them desirable as cleaning agents has increased the use of organic solvents in industrial cleaning. There are a number of chlorohydrocarbons which, although closely related chemically, have physical and chemical properties which differ enough to allow selection of one solvent for a particular application. (Refer to Solvent Table, page 3.)

As a result of tests made to determine solvent power, the following decreasing order of effectiveness was indicated.

- 1. Chloroform
- 2. Trichloroethylene
- 3. Methylene Chloride
- 4. Methylene Chloride Freon 113
- 5. Carbon Tetrachloride
- 6. Methyl Chloroform
- 7. Perchloroethylene

The Kauri-Butanol number as specified by solvent manufacturers was also used as a guide in formulating the above listing. The Kauri-Butanol test is used to compare the solvent power of industrial solvents; the higher the Kauri-Butanol number, the greater solvent action.

The stability of organic compounds is dependent upon the conditions of use. In general, the chlorohydrocarbons are stable under normal operating conditions. However, at certain conditions the chlorinated solvents will decompose through oxidation, hydrolysis, or pyrolysis, or a combination of these. The presence of air or other oxygen source and heat will cause the oxidation of chloroform to proceed according to the equation

$$2CHCl_3 + O_2 - 2COCl_2 + 2HCl.$$

Moisture in contact with the chloroform may cause the hydrolysis to proceed as

$$CHCl_3 + H_2O \longrightarrow COHCl + 2HCl.$$

The oxidation and hydrolysis reactions of chloroform are not necessarily representative of what occurs with other chlorohydrocarbons. All of the chlorinated hydrocarbon solvents will break down in flame or in direct contact with hot surfaces of between 750° to 950°F.

Stabilizers are not added to react with decomposition products but to prevent the decomposition from occurring or to keep it low. Stabilizer formulations have to have a good antioxidant in order to limit the degree of solvent oxidation. The alkyl amines are good antioxidants and, because of their alkalinity, will also react with any acids in the system. One weakness in their use is that they not only react with mineral acids, but also with any fatty acids that may be in the system. Once the amine reacts with a fatty or mineral acid, an insoluble salt is formed, producing a loss of antioxidant. Industrial practice has been to provide one inhibitor which will prevent oxidation but will not react with

CLEANIN? SOLVENTS

	Formula	Molecular Weight	Boiling Point OF	Freezing Point Op	Specific Gravity 200/400	Density 1b/ft 680P	Density lb/gal.	Solubility in water wt. \$ 68°F	Solubility of water in solvent wt. % 7770p	Latent Heat of Vaporization at B.P. BTU/1b.	Vapor Pressure at 750F in, Hg.	Evaporation Rate (Ether = 100)	Flash Point OF	M.A.C.	Hesique I	Diffusivity In Air 25°C, 1 atm. sq.cm./sec.	Kauri Butanol Mumber 770F	Cost 3/gal.	
CARBON TETRACHLORIDE	7100	153.84	170.2	0.6-	1.595	99.53	13.31	90°0	0.012	84.2	4.1	36	None	25	0,001		8	1.90	
METHYLENE CHLORIDE	CH2C12	76.78	104.2	-142.1	1,326	83.37	11.07	1.32	0,170	141.7	17.2	3	None	2 00	0,00075	0,091	109	1.74	
TRICHLOROBIHILENE	C2HC13	131.40	188.6	-122.8	1,465	27.16	12.22	0.11 (77%)	0.027	103.0	2.91	%	None	200	9000*0	0,073	130	1.87	
CHLOROPORM	снст	119.39	142.2	-92.3	1.489	92.91	12.42	0.82	0.083	106.7	7.9	50	None	100	0.001	6.079	508	2.36	
ETHTLENE DICHLORIDE	C2H4C12	76.97	182,3	-31.5	1.257	78.14	10.49	0.869	0,15	139.1	3.1	25	3 6	8	0.00			1,36	
HETHIL CHLOROPORM (1,1,1 TRICHIOROETHANE)	C2H3C13	133.42	161.8	8 2	1,319 (25°/25°C)	82.1 (770P)	10.97 (77%)	0,128	0.034	4.56	5.4	37	None	8	0,001	990.0	130	1.7	-3-
PERCHLORETHYLENG	C2C14	165.85	250.2	8. 2	1.623	161.5	13.55	0.015 (777°F)	0.0105	0.0%	6.0	12	None	800	0,000	290°0	88	2.06	
METHIL CHLORIDE	снэсл	67°05	-10.65	-143.7	0.918	55.9	7.5	0.65	0.26	184	166		Below 32	001	10°0				
PREON-11	cc138	137.4	74.8	7168	1.4876	92.7 (70ºP)	12.21 (86°P)	0.14	600*0	78.31	30.5	t8	None	1000	0.001	0,080	8	3.23	
FREON 112	c_2 CI μ P2	203.8	199.0	62	Solid	102.4 (80 0?)	13.65 (86°P)	0.013	0.000	0.14	2.64	12	None	8	0.001	990°0	٤	14.05	
FREON 113	2c13F3	187.4	117.6	-31	1.5765	98.3 (70°F)	12.95 (86%)	0.017	600.0	63.12	12,2	ব	None	1000	0,0003	990° 0	32	8.35	
METHYLENE CHLORIDE- PREON 113 AZEOTROPE			110		1.35 (770°P)	83.77	11.2					7.	None	8	0.05		127	4.75	

mineral acids, and another inhibitor to react only with the acids. Thus, no loss of antioxidant will occur.

Another inhibitor used in some chlorohydrocarbons is added to deactivate any metal chlorides that might be formed by the reaction of HCl with the metal. The alkyl amines will not limit the formation of metallic chlorides, except for its capacity to react with the acids according to the equation

However, the salts formed are as corrosive as HCl and will reduce the amount of antioxidant inhibitor.

No information is available concerning the inhibition of hydrolysis. The best approach to limiting hydrolysis is to maintain as dry a system as possible and to operate at normal temperatures.

The chlorohydrocarbons must therefore be used at temperatures at which oxidation, hydrolysis, or pyrolysis are reduced to an acceptable rate. Trichloroethylene, perchloroethylene, methylene chloride, and chloroform are quite stable even at their boiling points.

In selecting chlorohydrocarbons, only the oxidatively inhibited solvents should be considered.

Upon evaporation, nonvolatile impurities, a part of the nonvolatile inhibitors, and nonvolatile decomposition products will be left behind as a residue. Consideration must be given to the amount of residue and also its constituents, when selecting solvents. A residue of 0.001% by weight or less is acceptable for oxygen service.

The stabilizer will not last indefinitely. When the stabilizer concentration is low and when the solvent is used under conditions which are favorable for solvent degradation, the stabilizer will eventually be depleted. Procedures must be established in each application of solvents to determine the level of stabilization which remains after use. When the stabilizer concentration is ineffective, new solvent should be used.

Pure, dry chlorinated hydrocarbons themselves are noncorrosive to most of the common engineering metals under normal conditions or where acidic decomposition products will not be formed. Elevated temperatures and the presence of water will increase corrosive action.

Aluminum should not be degreased under conditions where hydrolysis or oxidation of the solvent may occur. The hydrochloric acid may react with the aluminum and in the presence of methyl chloride could promote the formation of aluminum alkyl halides. These products will react spontaneously with air with almost explosive violence. These metal alkyls are formed by the reaction of aluminum and the methyl chloride above 250°F. The other chlorinated solvents will not react similarly. Since the normal procedures of cleaning for oxygen service do not exceed this temperature, there is no hazard. However, heat from an external source (welding torch, hot surfaces, etc.) must be removed from areas where solvents are in use.

METALS SOLVENTS ON EFFECT OF

Solvent*	Copper	Aluminum	Steel	Monel	Brass	Nickel	Lead	Zinc	Silver
Pure Solvent									
Carbon Tetrachloride	CB CB	ပ	CB	NB	CB	æ	CB	N	
Methylene Chloride	N	×	Z	z	Z	Z	Z	Z	
Trichloroethylene		Non-corrosive up to 248°F	sive up	to 248°F					
Chloroform	NB	C.B	CB	NB NB	NB				NB
Ethylene Dichloride		Non-corrosive up to 212°F	sive up	to 212°F					
Methyl Chloroform	ပ	ပ	Z	Z	ပ	Z	Z	Z	z
Solvent-Moisture									
Chloroform	CB	CB	CB	NB	CB				NB BNB
Trichloroethylene		Non-corrosive up to 248°F	dn ears	to 248°F					

* Pure solvent - inhibited grade
C Corrosive at room temperature
N Non-corrosive at room temperature
CB Corrosive above boiling point
NB Non-corrosive above boiling point

Aluminum may be safely degreased in properly stabilized boiling trichloroethylene. Proper control must be maintained and the time of contact must be limited so as to prevent decomposition of the solvent by finely divided aluminum or aluminum corrosion products. In the selection of solvents, consideration must be given to the ease with which the material of construction will oxidize, so that corrosion products will not react with the solvent nor promote reactions by catalysis. Methyl chloroform is unusually corrosive toward aluminum at room temperature. The inhibited grade of methyl chloroform (also named l,l,l-trichloroethane) should always be used.

The degree of toxicity of the chlorohydrocarbon solvents varies from carbon tetrachloride, which is the most toxic, to solvents which are less toxic than common ether. The values of toxicity are specified by "maximum allowable concentrations" or "threshold limits." These values refer to the maximum allowable tolerable concentration of the solvent vapors in the atmosphere for continued eight hour daily exposure, without ill effects.

Volatility and evaporation rates, as well as toxicity, determine the need for proper safety precautions for ventilation; for example, the M.A.C. of methylene chloride is 500 ppm, that of trichloroethylene is 200 ppm. It would appear that under similar conditions the methylene chloride would be two and one half times as safe as trichloroethylene. However, the evaporation rate is about twice that of trichloroethylene, thereby producing a richer atmosphere of methylene chloride than would exist for trichloroethylene in the same period of time. When the evaporation rate is considered, it is evident that ventilation requirements will be similar for both solvents.

Ventilation is necessary when the chlorohydrocarbons are used and the necessity for floor level circulation should be recognized because the vapors are heavier than air. Gas masks that work independently of the surrounding atmosphere or masks that have air hoses can be used. When using trichloroethylene, the regenerative type of mask should not be used. Trichloroethylene will react with the caustic to form dichloroacetylene which is toxic and explosive.

Contact of skin with the chlorinated solvents and their vapors should be avoided because absorption through the pores may produce the same physiological effects as inhalation and by removing natural skin oils can cause excessive skin dryness. In some cases dermatitis is caused by the solvent itself. Contact with the eyes should be particularly avoided because of the sensitivity of these organs. The eyes generally inflame and callouses can form on the cornea of the eyes. Obviously, the solvents should not be taken internally.

Employees should be educated in the use of solvents. They should be trained in the use of personal protective equipment and its purpose. Solvent resistant gloves and aprons and chemical safety goggles should be used when handling solvents. The use of solvents for personal purposes should be discouraged because of the potential hazards to personal health.

All solvent tanks must be labeled and the type of solvent should be noted. Storage of solvent tanks should be underground or in a cool dry isolated area and should be such that corrosion of tank and parts is avoided. Special attention should be placed on segregating solvent storage from strong alkalies. All unburied pipe lines should be grounded to protect them from lightning and static electricity and should be installed so as to make it impossible for power lines to fall on them. The liquid should be pumped through piping to its place of use

so as to minimize personnel handling and vaporization to the atmosphere. The use of rubber and plastic for transfer hosing should be avoided, since in some cases the material will be dissolved by the solvent. Compressed air should never be used to remove solvent from drums.

Spilled solvent should be cleaned up immediately. Compressed air or fans should not be used to dry up spills because of the danger of increasing solvent vapor concentration in the atmosphere. Mops and rags should be used to soak up spills and they should be dried outdoors. Solvent soaked rags should never be thrown in waste cans.

B. Water Soluble Cleaning Solutions

The removal of loose particles, weld particles, chips, and filings in oxygen service lines is as necessary as removing hydrocarbon contamination, for by impact or friction these particles may ignite the system. The alkaline and acidic water soluble cleaning agents effectively remove these particles as well as scale, rust, lubricants, and mill oils.

The cleaning mechanism of these particular cleaning agents is that of loosening the contaminants from the base metal, forming soaps by saponification and suspending the loosened particles in the solution itself. Most applications require the use of the solutions at 160° to 190°F.

Application of water soluble cleaning solutions is usually in the fabrication and construction stages, rather than after the equipment has been in operation. The type of soil removed by these cleaning agents will not be formed in the normal operation of process equipment in oxygen service. After the plants are "buttoned up," it is most desirable to exclude water from the plant. During the fabrication and construction stages all parts are accessible and complete drainage and drying can be accomplished.

Water soluble cleaning solutions have the necessary properties required of a safe solvent. They are nonflammable, nontoxic, and will not leave a residue if properly rinsed; they are noncorrosive to most metals. This statement is rather specific in covering all of the commercial types of water soluble cleaning solutions. It is therefore necessary to specify the use in oxygen systems when a cleaning agent is to be purchased. Solutions for oxygen service are available with the required safe properties.

Almost all of the water soluble cleaning agents are proprietary solutions. Therefore, in the selection of such cleaning agents, it is necessary to discuss the application and requirements expected of such solutions with the manufacturers. Most of the larger distributors will consult with users and offer their experience and laboratory facilities in determining the best cleaning agent to use.

The alkali cleaners are generally strong enough to react with any free fatty acids present. The saponification of the fatty acids to form soaps, which in turn serve as wetting agents, enhances the cleaning action of the solution.

Such characteristics are combined with the ability to neutralize acid dirt and maintain simultaneously the pH of the solution at the necessary level for effective cleaning as well as exerting specific protective reactions toward soft metals.

It is generally recognized that alkali solutions show practically no cleaning effects below a pH of 8.3. The active Na₂O content is an important factor when estimating the value of any particular alkali cleaner. That portion of the total Na₂O available above pH of 8.3 is conventionally termed active Na₂O. Part of the active Na₂O will be consumed by the neutralization of acidic contamination, usually fatty acid which is saponified to form soaps. The pH of a solution is a measure of its power to clean and, as such, the tougher the job, the higher the pH required.

Fine particles of metal and debris will be suspended in the cleaning solution. It is a necessary property of the water soluble cleaning agents to maintain this suspension so there will be no residue. When the solution is removed from the part, it should carry the particles with it. A final rinse with water, after the part is neutralized, will remove the final traces of solutions and heavier particles which have been loosened from the metal surface.

Almost all of the alkaline solutions will show improved cleaning power if wetting agents are added to lower the surface tension of the solution. The use of soap as a wetting agent and the formation of soaps by the neutralization of fatty acids may be detrimental, in that the soap may be precipitated by calcium and magnesium salts, the usual forms of hardness found in water. There are, however, synthetic wetting agents which are not adversely affected by the hardness of water. Although they aid in the wetting of the dirt and its separation from the parts, the particular benefit of wetting agents is better rinsing of the metal surface.

When relatively hard waters are used, the use of tetrasodium pyrophosphate along with the alkali will improve the cleaning operation. Certain types of polymerized phosphates have the ability to tie up the calcium so that the soaps will not be precipitated. In some cases, these phosphates will even decompose the calcium soaps already formed.

The function of silica in cleaning operations is measured in quick wetting of dirt, in complete emulsification of oils, and in better suspension of the removed dirt. Silicate agents control the alkali and maintain the pH until practically all of the alkali is used. The ratio of silicate to sodium oxide can be controlled to achieve the cleaning characteristics required.

However, sodium metasilicate is a definite crystalline form with a fixed composition. The balanced components of one part of sodium oxide controlled by and working with one part of soluble silica contributes to the improvement of cleaning properties such as wetting, emulsification, defloculation, and prevention of soil redeposition. Metasilicate, after loosening grease, breaks it up into small droplets and suspends these throughout the cleaning solution, permitting the dirt to be easily flushed away with water.

The water soluble acid cleaning agents should be inhibited to prevent attack on metals. The acid solutions remove scale and rust right down to the bare metal. Metallic salts and oxides are converted into substances which are readily soluble in water.

C. "Freon" Solvents

In overall solvent power "Freon" solvents rank above hydrocarbons and below chlorinated solvents. The "Freon" solvents have the ability to satisfactorily dissolve oils and greases without harm to the metal.

The "Freon" solvents, in addition to their solvent properties for oil and grease, exhibit a "washing action" that materially aids the cleaning action. Their high density and low surface tension enables them to wet the surface of most materials and wash away dirt and sludge. Metal surfaces are often thoroughly cleaned when agitation or solvent flow is used, even though the gums and oxidized materials are not completely dissolved by the solvent.

The presence of fluorine atoms in the molecules promotes stability which is higher than that normally found in organic compounds. The hydrolysis rate for the "Freons" is low compared with other halogenated compounds. Conditions of temperature, pressure, and the presence of other material greatly affect the rate.

Most of the commonly used metals—steel, cast iron, brass, copper, tin, lead, and aluminum—can be used satisfactorily with the "Freon" compounds under normal conditions of use.

At very high temperatures (600-700°F) some of the metals act as catalysts for the breakdown of the solvent. The tendency of metals to promote thermal decomposition of the "Freon" compounds is in the following general order:

Least Decomposition

Inconel
18-8 Stainless Steel
Nickel
Copper
B40 Steel
Aluminum
Bronze
Brass
Silver

Most Decomposition

Zinc is not recommended for use with "Freon" solvents. When water may be present, magnesium alloys and aluminum with more than 2% magnesium should not be used with "Freon."

The "Freon" solvents are safely used in contact with aluminum up to 400° F, even when traces of moisture exist. At room temperature, there is no corrosive action on aluminum, even if the solvent is saturated with water.

D. Hazardous Solvents

The cleaning agents which have been discussed up to this point, within their noted limitations, are acceptable for cleaning equipment intended for oxygen service.

A brief review of nonacceptable solvents is warranted so that in an emergency an educated decision will dictate the selection of a suitable substitute.

All solvents used on equipment which will be used in oxygen service must be nonflammable. The Cleveland Open Cup Test should reveal no flash point. It would be wise to eliminate entirely the use of any flammable solvent anywhere in an oxygen plant or in the fabrication of oxygen equipment. Gasoline, benzene, petroleum base solvents, etc. should never be used for oxygen service. Methyl chloride and ethylene dichloride, although chlorinated hydrocarbons, should not be used because of their flammability.

Solvents which have a low M.A.C. should not be used when adequate ventilation cannot be established. Under no circumstances should carbon tetrachloride be used.

II. CLEANING METHODS

A. Cold Cleaning

The application of organic solvents at room temperature is commonly referred to as "cold cleaning." The solvent is usually applied by wiping, dipping, flushing, or spraying.

Evaporation rates of good cold cleaning solvents should be rapid enough for the cleaning operation, yet slow enough to allow effective solvent action and removal of soil. Evaporation should be such that moisture will not condense on the equipment being cleaned.

When process equipment is cleaned in place after operation, the flushing method is most satisfactory. The solvent used should have a low boiling point and high vapor pressure so that all of the solvent will be removed by purging with a heated stream of clean, dry air or nitrogen. Methylene chloride or an azeotrope of methylene chloride with Freon 113 is commonly used for this particular cleaning procedure. Although we have had no experience in its use to date, trichloromonofluoromethane (Freon 11) could possibly be used as a flushing solvent. Its low boiling point of 74.8°F is ideal for removal from the equipment. However, it may present problems of handling and storage.

In wiping operations, selection of the proper wiping material is important. Only clean lint-free cloth or paper should be used. Cloth is preferable, since the abrasion of the paper on the metal surface will usually cause the paper to break up. Mops are sometimes used when large equipment is to be wiped clean.

Cold cleaning by spraying is usually used when the internal portion of large equipment is to be cleaned. Common applications are LOX storage tanks, surge tanks, columns, and some of the bigger sized pipes.

The application of cold cleaning by dipping is probably the most well known. However, to insure removal of the soil and residue, the final cleaning is usually by wiping, flushing, or spraying.

Other popular cold cleaning solvents are chlorothene, perchloroethylene, and trichloroethylene.

In completing the process of cold cleaning, it is essential that all of the solvent is removed, preferably by evaporation. A recent incident which was published in the August 1959 issue of the "Safety Newsletter" of the National Safety Council's Chemical Section related how two workmen were overcome when arc welding caused sufficient phosgene evolution from residual trichloroethylene.

B. Vapor Degreasing

Suspension of parts in the vapors of solvents so that the pure condensed liquid rinses the part free of soil is called vapor degreasing. The vapor stage is sometimes used in combination with immersion in warm or boiling solvent or spraying with warm solvent as may be required by the shape, size, and type of part to be cleaned and the nature of the soil to be removed. Some of the commonly used combinations are:

- 1. Warm liquid-vapor
- 2. Boiling liquid-warm liquid-vapor
- 3. Vapor-spray-vapor

The unique feature of vapor degreasing, no matter which combination is used, is that the part always leaves through the vapor and is washed by pure solvent which has condensed on its surface. The condensation thus heats the part to the evaporation temperature of the solvent and upon removal from the degreaser is dried by evaporation.

It is advantageous to use a solvent with a high boiling point so that sufficient time is available for the cleansing action before the part reaches the evaporation temperature. The use of vapor degreasing for thin-walled parts with low heat capacity should be carefully reviewed since the evaporation temperature may be reached before the part is thoroughly cleaned. In such a case, a vapor-spray-vapor combination might be required.

Selection of solvents for vapor degreasing should be based on the following required properties:

- 1. Low latent heat of vaporization
- 2. Ideal boiling point
- 3. High stability
- 4. High vapor density

Operation of the degreaser should be discontinued when the efficiency of the solvent is impaired by contamination. Cleanout is recommended by manufacturers when the degreaser must be operated at 195°F for trichloroethylene and 256°F for perchloroethylene.

A regular cleanout schedule should be established when the nature of the residue is determined and after consultation with the degreaser manufacturer. Accumulation of metal particles and/or the amount of dissolved oil will determine the cleanout frequency. The contamination will increase the heating load and the boiling point, making distillation more difficult.

If it is necessary to enter the degreaser for cleaning, all of the solvent and vapors should be removed. There should always be at least one workman outside the degreaser observing the cleanout operation. Those individuals actually working inside the degreaser should wear masks which are provided with a source of outside air.

Excessive loss of solvent and high vapor concentrations in the air should be minimized by controlling the following possible sources of solvent waste:

- 1. Losses into air due to improper heating or cooling.
- 2. Drafts over degreaser.
- 3. Covers off degreaser during idling.
- 4. Drop in vapor line due to excessive load.
- 5. Removal of solvent on parts.
- 6. Too rapid entry or removal of parts.
- 7. Spraying above vapor line.

Failure to turn on cooling water to the condenser and excessive heating of boiling solvents are common causes of high vapor concentration in the air. Most of the degreasers are supplied with thermostatic controls to prevent such conditions.

Localized hot spots on heater surfaces, excessive boiling points, and accumulation of contaminants that might catalyze hydrolysis of the solvent must be prevented in the operation of vapor degreasers.

Sufficient condensing surface should be provided to condense the vapors generated by the maximum heat input. The surface should be extended to cover all four walls, a portion of which should be an integral part of the walls to prevent loss of vapors due to convection currents.

Additional height above the vapor line is included in the design of degreasers to minimize the loss of vapor due to the circulation of the surrounding air.

The degreaser should never be installed in drafts from ventilators, fans, doors, or windows. The distinction between normal circulation and direct drafts should be noted. Natural circulation of air will merely dissipate the solvent vapor which normally evaporates from the degreaser. However, strong drafts lift vapors from the degreaser.

The machine should be operated such that the vapors will not be violently disturbed. If excessive loads are introduced, there will be a drop in the vapor level. This will cause air to enter the void. When the original vapor level is restored, the air volume mixed with a high concentration of solvent vapor will be forced into the atmosphere.

To prevent excessive disturbance of the vapor, parts should be introduced and removed from the degreaser at a rate of about 11 feet per minute.

When spraying is included in the cleaning process, the nozzle should be located well below the vapor level so as to minimize vapor disturbance. When equipment is transferred from one compartment to another, it should be done below the vapor level.

C. Detergent Cleaning.

The application of water soluble cleaning agents in the cleaning of material is usually by dipping or spraying at operating temperatures of 160° to 190°F.

Prior to installation in the field, piping is cleaned in tanks or troughs containing the hot solution. The temperature can be maintained with electric heaters or steam coils. With manual agitation and water rinsing or spraying, equipment is cleaned at considerably less cost than solvent cold cleaning.

Long lengths may require flushing or mop cleaning with the solution.

Whenever equipment which is heavily contaminated with mill oils or heavy metallic deposits and is easily handled and separated from the cryogenic equipment of the plant is to be cleaned and degreased, the use of detergent cleaning is probably the most practical and economical.

D. Ultrasonic Cleaning

A recent innovation in the metal cleaning field is the use of high frequency waves in the cleaning of soil from metal. Ultrasonic cleaning devices convert electric current to sound waves inaudible to the human ear. As waves are projected through the bottom and sides of the tank, they create tiny bubbles in the liquid solutions. As quickly as the bubbles form—40,000 or more times per second—they collapse with tremendous force relative to the size. This action, known as cavitation, blasts grease, dirt, and other contaminants from the surfaces of the parts to be cleaned. Sonic cleaning reaches all surfaces touched by the cleaning solution, even crevices and pores. The cleaning solutions can be water soluble agents as well as the chlorohydrocarbon solvents.

Multi-stage operations are advantageously used in ultrasonic cleaning. Heavy soil deposits are removed in the initial stage by dipping or spraying with cold or warm solvent to prevent early contamination of the sonic bath. Usually a rinse with clean solvent will follow the sonic bath.

SELECTION OF CLEANING METHODS

The cold cleaning method is used in application to large equipment by either flushing, spraying, or wiping in place piping and process equipment by flushing, and smaller equipment when this method is dictated over the use of vapor degreasing or the use of water soluble cleaning agents. Usually the vapor degreasing and water soluble cleaning methods are not used for cleaning oxygen equipment that has been in operation. In cleaning a plant, the economics of installing a vapor degreasing system for only a minor portion of the equipment to be cleaned (valves, fittings, etc.) do not warrant its use. The problem of completely drying water from the inplace process equipment after rinsing out water soluble cleaning agents eliminates the use of this type of cleaning agent.

In the fabrication shop where the quantity of small equipment can warrant its use, vapor degreasing and water soluble agents may possibly be better than cold cleaning.

If ordinary cleaning methods produce acceptable work, ultrasonic cleaning is not necessary. However, when sonic cleaning eliminates or minimizes manual brushing, wiping, or handling of parts, it can be economically practicable. When cleanliness standards are very high or when the shape makes inspection difficult, ultrasonic cleaning may be required.

INSPECTION

When cleaning has been completed, the equipment should be purged with warm, dry, oil-free air or nitrogen and inspected for cleanliness. There are several methods which can be used for inspection:

- 1. Visual inspection.
- 2. Water break test.
- 3. Wipe test.
- 4. Ultraviolet light.

The equipment should be inspected visually for residual material. Particular attention should be given to places of possible entrapment.

Demineralized water should be run over as much area as possible and the areas should be water break free for at least five seconds.

Using a clean, lint free wiping media, critical points of equipment should be wiped. The smudge produced should be inspected visually for contamination and should also be viewed under an ultraviolet light.

An ultraviolet light source will cause most cutting oils and machinery lubricants to fluoresce. However, this test is not sensitive to all types of carbonaceous contamination, such as animal and vegetable fat.

When inspecting equipment that is in place, purging must continue until all outlets are warm and no odor of solvent exists.

BIBLIOGRAPHY

- 1. Chemical Abstracts 46, 11506g; 46, 3647c; 47, 7423c; 48, 6946d.
- 2. Chemical Engineering 62, No. 3, p. 260; 62, No. 13.
- 3. Chemical and ongineering News 32, p. 1276; 33, p. 3712, 3844, 4048.
- 4. The CP Chemical Solvents, Inc., "Organic Solvents and Chemicals" (pamphlet).
- 5. The Chemical Mubber Co., "Handbook of Chemistry and Physics" (1953-54).
- 6. Chemical Week 72, No. 18, p. 56; 74, No. 16, p. 74.
- 7. Detrex Corporation Miscellaneous literature on metal cleaning.
- 8. DeVoldre, J. J. and M. J. Skrypa, "Methylene Chloride for Maising Solvent Flash Points," <u>Fetroleum Processing</u>, Nov., 1955
- 9. Doolittle, Arthur K., The Technology of Solvents and Plasticizers, John Giley and Sons, Inc., New York, 1954
- 10. E. I. DuPont de Memours and Co., Inc., "Vapor Degreasing with DuPont Triclene D;"
 "Metal Degreasing with Chlorinated Solvents;" "Methylene Chloride--Physical,
 Chemical, and Thermal Froperties;" "Protecting the Public Health." (pamphlets)
- 11. Biseman, B. J., Jr., "Effect on Blastomers of Freons and Other Halohydrocarbons," Reprint from Refrigerating Engineering, Dec., 1949
- 12. Fieser, Louis F. and Mary Fieser, Organic Chemistry, D. C. Heath and Company, Boston, 1950.
- 13. General Electric, Health Information Bulletin No. 15.
- 14. Hardin, B. L., Jr., "Carbon Tetrachloride Poisoning--a Review," Reprint by John B. Moore Corp., Nutley, N. J.
- 15. Jordan, T. Marl, <u>Vapor Pressure of Organic Compounds</u>, Interscience Publishers, Inc., New York, 1954.
- 16. Lange, Morbert Adolph, Handbook of Chemistry, 1946.
- 17. Oil, Paint and Drug Reporter 169, No. 26.
- 18. Ferry, John H., Chemical Engineers' Handbook, 1950.
- 19. Petroleum Frocessing 10, No. 6, p. 918.
- 20. Fetroleum Refiner 32, No. 11, p. 124.
- 21. Shriner, Ralph I. and Reynold C. Fuson, <u>Identification of Organic Compounds</u>, John Wiley and Sons, Inc., New York, 1950.

- 22. Solvay Frocess Division, Allied Chemical and Dye Corporation, "Chloromethanes" (pamphlet).
- 23. Stull, Daniel R., "Vapor Pressure of Pure Substances," <u>Industrial and Engineering Chemistry</u>, 39, p. 517.
- 24. "Ullmanns Lncyklopadie der technischen Chemie," 5 Band, Urban und Schwarzenberg, Lunchen-Berlin, 1954.

Perchloro- ethylene									×						
Methyl chloroform					×			×							
Prichloro- ethylene	×	×	×		×	×		×	×	×	×	×	×		
Chloroform								×	×			×	×	×	
Methylene Chloride			×	×	×		×	×	×			×		×	
Company Address	225 W. 34th St. New York 1, N. Y.	155 E. 44th St. New York 17, N. Y.	254 W. 31st St. New York 1, N. Y.	74 Dod St. Elizabeth, N. J.	60 Park Place Newark, N. J.	14331 Woodrow Wilson Box 501 Detroit 32, Mich.	12 South 12th St. Philadelphia, Pa.	Midland, Michigan	Du Pont Bldg. Wilmington, Del.	1945 E. 97th St. Cleveland 6, Ohio	90 West St. New York 6, N. Y.	155 E. 44th St. New York 17, N. Y.	60 E. 42nd St. New York 17, N. Y.	61 Broadway New York 6, N. Y.	
Company Name	Allied Industrial Products Co.	American Mineral Spirits Co.	Baird Chemical Corp.	Chemsol, Inc.	The C.P. Chemical Solvents, Inc.	Detrex Corp.	Diamond Alkali Co.	Dow Chemical Co.	E. I. du Pont de Nemours & Co.	Harshaw Chem. Co.	Hummel Chem. Co.	McKesson & Robbins	Merchants Chem. Co.	Solvay Frocess Division	

AIR SEPARATION PLANT CONTAMINATION:

HISTORY, SAMPLING, AND ANALYSIS

Paper delivered by H. H. Master, Operations Safety-Service Manager at the Plant Managers Safety Meeting at Creighton, Pennsylvania

February 28 and March 20, 1968

Air separation plant contamination — our efforts to determine the magnitude within our own plants, our methods to reduce it, and the action we have taken to limit inevitable contamination caused by weakness in processes over the years — covers quite a bit of territory. I am sure many of you have wondered from time to time just what has been done or what we are doing with the samples and data shuffled back and forth between the facilities and Trexlertown. Although a good many of the people who have been with us for some time now realize the importance of these samples, I am hoping we can now enlighten them even further as well as impress our newer plant managers with their role in this continuing program — its effect on the workloads, its economic advantages, and finally, and most important, its role in creating the safest plant operation practical.

By contamination in these plants we generally mean all hydrocarbons and, to a lesser degree, the oxides of nitrogen. Acetylene itself is uppermost in our minds, as it is believed to be the culprit in most of the industry reboiler explosions (or "energy releases", if you will). Solubilities, initiating mechanisms in explosions, and various technical details are subjects in themselves and will only be touched on here. My primary purpose is to describe for you our methods of determining the amount of contaminant within the unit, our means of reducing or controlling these amounts, procedures and equipment for contaminant removal, and your part in the program. I will touch on plant solvent washout, oxygen pump solvent cleaning, desiccant changes, defrosts, and batch sampling.

1. THE HISTORY

Plant solvent washout started at our company in 1958. With the advent of a corporate Safety Department in 1959, our safety program became more complex and more important, in keeping with our phenomenal growth. The first requirements called for solvent washout of exchangers and condensers every year, with samples of the solvent to be submitted to the laboratory to help in determining the washout frequencies. Unfortunately, we were inexperienced in sampling techniques and washout procedures and we only started to realize helpful data in 1961.

Our Aliquippa plants were the catalyst that prompted us to take a decisive look at plant washouts and means of reducing contamination. Fortunately, the problems at these plants were not typical, but their history does indicate our management's interest and the lengths to which we will go in the interest of safe operations. I will use this history to present my case.

The Aliquippa ficility with two 115 T/D split-cycle plants, was our first venture into company-owned, on-site tonnage operations. A simplified flowsheet is shown in Figure 1. These plants started producing product in 1957, and the first serious contamination was discovered in 1961. The main air heat exchanger delta-T had spread because of oil in

in the oxygen circuit, not the usual moisture or carbon dioxide. The entire plant, including the regenerator stones, all 200 tons for both plants, were washed. About 3000 gallons of solvent was required to wash each plant. Laboratory equipment and technicians were sent to the site, and the solvent was analyzed as the samples were taken. Qualitative solvent analysis and piping inspection convinced us that the majority of this contamination was due to oil saturation of regenerator stones and final breakthrough of the oil at the cold end. An energy release in the Byron-Jackson oxygen pump in 1962 (which I will discuss later) convinced us that solvent cleaning the stones was not the answer, as the solvent sprinkling the top of the stone bed probably caused channeling of the solvent through the bed, letting it seep through. We then changed the regenerator stones.

Of course, in addition to determining the quantity and types of materials involved, the ultimate goal was to reduce the contamination in the plant itself. Each step took longer than we liked, but time was needed to test our efforts. Some of the work we did and the changes we made were:

- 1. Routine washout of the plant and stones. Finally, changing of the stones.
- 2. Analysis of the stones, used solvents, and desiccants. Infrred analysis to determine types of contaminants.
- 3. A water-scrub tower had been used as a cooler and as a means of cleaning out entrained water-soluble oil from the lubrication of the first two compressor stages before it went to the regenerator. An intercooler was added upstream of the scrubber to increase cooling and condensate knockout. Also, high- and low-pressure air had been passing through the scrubber. The portion going to the third through fifth stages and then to the driers was repiped to bypass the scrubber and thereby decrease the load on it.
- 4. Eventually the water-soluble oil in the first two stages of cylinder lubrication was replaced by Cellulube 550. Tests on the water-soluble oil had proved it to be less soluble than represented, and the low vapor pressure of the Cellulube also contributed to more effective separation in the condenstate traps. The soluble oil also had formed acids in new coolers. which produced leaks in the cooler shells in less than 3 weeks.
- 5. Warner-Lewis mist eliminators were installed in the low-pressure air line, and eventually test of low-pressure air contamination indicated that we could shut down the water scrub tower. The mist eliminators are three-stage units. The first stage is a condensate trap; the second is a set of coalescer cartridges, from which the air-mist mixture emerges as air and droplets. The air and droplets then pass into the separator cartridges of the third stage; the droplets stay on the inlet side of the filter, and the clean air passes into the system. Oil and water is

blown off the bottom as in the condensate traps. Coalescer and separator filters of various sizes were tried before we found the right combination.

6. The plant with the smaller hydrocarbon adsorbers had a history of higher contamination levels and rates. These adsorbers were replaced by vessels similar to those in the other plant.

The exchanger oxygen circuits at the Aliquippa plants are now washed once every 18 months and the plant every 3 years. At one time we were cleaning the oxygen circuits as often as every 2 months, and plant washouts, in one case, were only 3 months apart. Whereas solvent analysis of one plant had indicated an average contamination rate of better than 7 pounds per year in the plant in 1962, our 1966 results show less than 0.6 pounds per year. Less than one-tenth of what it had been! We had installed spool pieces with silica gel in a parallel circuit of the lowpressure air line to determine contamination in the air. A calculated 5 percent of the low-pressure air passed through this gel. Initially, airentrained solids and oil mist plugged up the screens meant to retain the gel, and they collapsed before we could even put the gel in the spool piece. By 1964, however, this low-pressure air contamination was down to 93 ppb and by 1966 to less than 10 ppb. I might add here that problems at our New Johnsonville plant, an essentially similar process to Aliquippa, now give us some reason to doubt the accuracy of this means of determining low-pressure air contamination; however, the change at Aliquippa was so great it was obviously an improvement.

I repeat that the contamination problems at Aliquippa were exceptional. However, we learned from this bad experience. Cleaning procedures and frequencies were developed, management and operators were taught new methods of contamination reduction and control, analysis procedures were developed, and new equipment was added to the processes. Many of the important cleaning techniques now in the Plant Operations Manual, procedure 1.05, were learned at Aliquippa.

Other process plants have had a few contamination troubles, (excepting low-pressure plants) and we have resigned ourselves to some degree that oil from lubricated compressors will continue to find its way through our barriers. Washout frequency extensions were granted to plants with these compressors after the plants were washed several times. Management and operators were taught about potential problems, and more conscientious inspection and maintenance of such supposedly routine items as lubrication rates and drier reactivation temperatures have produced safer operations.

2. SAMPLING AND ANALYSIS

A. Plant Solvent Washout

In the course of the program, we had to determine how often to wash out the plants. Criteria were difficult to determine, but we settled on a maximum of 3 pounds of soluble contaminanats in the entire plant, 1

pound in the condenser, or 1/2 pound in the heat exchanger oxygen circuit. The plant would be washed out as soon as any of the 3 levels were reached. With some practical considerations taken into account, these criteria have been our guideposts. These quantities may seem insignificant in a 400-ton plant, but even there it is quite probable there are some areas of dangerous concen ration and certainly nothing close to equal distribution. We have also worked on the principle that there will seldom be any extention of wash periods based on the results from one solvent washout. Only two washings, at least, of the same plant, or in some cases the washin of several plants with the same general process and contamination background, will justify an extension.

It may interest you to know just how much benefit we derive from solvent analysis, not only operationally by reducing contamination, but also economically. As I said before, our cleaning program did not get into full swing until about 1959. Just three years later, in 1962, we had 22 plants from 25 T/D to 115 T/D which had been operating for two years or more, and we had so reduced the frequencies of washouts that we were saving approximately \$4,000 a year in solvent alone. By 1966 we had 38 plants from 25 T/D to 250 T/D which had been operating for two years or more. and by further extending time between washouts and by reusing some solvent from low-pressure column and condenser circuits we were saving approximately \$9,000 a year. This may not seem like very much money in view of the magnitude of our total operation, but you must also consider that the labor to do the job costs from about half as much to as much as the solvent, and that the power in a large plant which is defrosted for cleaning alone can cost at least as much as the solvent. So, the saving is now up to about \$22,500 a year. There are also such items as product loss (which will vary with location) and contracts for haul-ins. I believe that washout and associated costs are now more than \$30,000 a year (plus production benefits) lower than they would have been in 1959 if we had had 38 plants then. Furthermore, our over-the-fence customers are happier, and our employees are free for other work.

Plant Operations Manual, procedure 5.07, gives present washout frequencies, which are now as high as 7 years, with 10 years tentative for several plants. This 10-year frequency is based on contamination levels from exchanger cleanings only, and these levels must then be related to data from similar circuits in other plants. Should the exchanger contamination increase significantly during the 10 years, we would naturally reschedule the washout.

The newer plants, with nonlubricated centrifugal compressors, do not require solvent cleaning. In theory (and in practice, to date) we should not have any problems here. Probabilities of extensions on other process plants are diminishing but there are still some possibilities. Someday we would hope to reach the ultimate frequency in lubricated compressor plants. Ideally, we will eventually have all nonlubricated equipment, and washouts will be a thing of the past. I guess we would all like to see that day.

In the meantime, you are helping yourself and the company by obtaining good representative solvent samples from the plant washout. Without a doubt, cleaning would be less frequent today if sampling were better. Sampling methods are explained in POM procedure 1.05. It is not a difficult task, but there are still many errors. Here are some simple reminders:

- 1. Always clean the can before taking the sample. Even in new cans there is usually some oil film to prevent rusting.
- 2. Solvent dissolves adhesives in the original cover gaskets on cans. Remove these gaskets, cut Garlock gaskets to size and soak them in the solvent to clean them before putting them in the caps. For double assurance, place clean aluminum foil over the top of the gasket. Use paint-type cans, if you can, because they have no gasket.
- 3. Always report quantities of solvent used for cleaning in each circuit.
- 4. The sample must be representative of everything drained. Years ago we had many cases in which just the first solvent discharged was collected. Drain all solvent, then take equal portions from each full drum and proportional amounts from those not completely full and put them in a single container.
- 5. Make sure that the Plant Solvent Washout Report (Form 3554) includes all the necessary information.

Analysis is done by evaporating 200 ml. of filtered solvent in a container. The container is weighed empty and clean and then again with the residue from the evaporation. Weights are taken to 1/10,000 of a gram, which is 1/4,454,000 of a pound. The difference in weights between the clean and used sample residues then gives us the amount of soluble contamination in 200 ml. Analytical reports are submitted in contamination in grams per liter of solvent. We then convert this figure to grams of contamination per gallon and multiply this figure by the gallons used in the circuit. In this way we derive a number reasonably close to the weight of the soluble contaminants removed from that circuit.

So now let's suppose that you did not replace the gasket or clean the can and so you contribute 1/20 gram (1/2270 of a pound) to 200 ml. of used sample. Also, let's suppose that you used 200 gallons of solvent in that circuit. Calculations will indicate that you removed 190 grams or about 0.45 pound of contaminants more than was actually in that circuit. If this error is in the oxygen exchanger circuit and you follow the criteria we have established, you would now have to clean the exchangers about every year even if you had no actual contamination. On the other hand, we have quite a few cases where the reference sample results are higher than the used sample and there would be no extension as we have no proof of improvement. In most cases this is probably due to dirty cans or gaskets.

Enough for plant solvent washout, unless you have some questions later. Let us discuss oxygen pump washout for a few minutes.

B. Oxygen Pump Solvent Washout

Pump cleaning is important because, first, the pumps are in the pure oxygen circuits and, second, they are in an area capable of supplying energy for detonation of fuel-oxygen mixtures. Again, it was at Aliquippa that an energy release within the centrifugal pump prompted our pioneering effort. Fortunately, the release did not go beyond the pump, but it did ruin it and make us realize the potential danger. In spite of fluid velocities through the pump case, which would lead one to suspect that oil would dissolve and carry through, it was found in the volutes and parting surfaces even after the reaction. At this time, I would like to quote a portion of a report on this incident which W. L. Ball presented at an AICHE meeting in 1962:

Reactions had occurred between the flanges holding the barrel to the suction head, and around the bolts holding the two halves of the volute case together, the bolts holding the bottom bearing housing to the case, and the bolts holding the case to the bottom flange of the suction head.

The worst reaction had occurred between the flanges of the barrel and the suction head. Here the metal clad asbestos gasket had been burned in two and grooves 1/4 to 1/2 inch deep had been flame cut into the faces of the flanges in two places. The burned areas covered about 1/4 of the face of the flange.

The burned areas around the bolts of the volute case centered around the bolt holes and spread outward in a diminishing pattern. In two instances, the reaction had reached the outer edge of the flange and had scorched the opposing inner surface of the barrel. This type of reaction had occurred at 12 of the volute case bolts and at four bolts holding the bottom bearing housing to the volute case and none of them had been interconnecting, each had been a separate and distinct reaction.

The unsupported halves of the case wear rings had been forced in all instances toward the lower stage. The degree of distortion of the ring between the ninth and tenth stages was the greatest, and the degree diminished progressively counting back to the first stage. This gave a very definite indication that the highest pressure had occurred either in or downstream of the tenth (final) stage. The fuel for the reactions was not hard to determine as free oil was found on all the flange surfaces mentioned as well as a light film on the outside of the case. As the pump had been thoroughly cleaned and inspected prior to original installation, this oil had accumulated during operation.

Apparently, the initial reaction occurred at the liquid-gas interface in the annular space between the pump barrel and the volute case. There was motion here because of the boiling liquid and possibly enough kinetic energy for the ignition of oil particles floating on the liquid surface. A hydraulic ram effect caused by the original combustion resulted in the failure of the drain valve and piping. This same hydraulic surge distorted the case wear rings. The pressure wave created by the original combustion slightly separated the flanged faces of the volute case (and the suction head to barrel flanges). Bolt tension brought the flanges back together with sufficient force to ignite the oil accumulations between the flange faces.

Prior to this time, pumps had been kept in cold standby service for indefinite periods by cooling the pump and then leaving the inlet valve open. The pump in which the energy release occurred was in this standby condition. It had been in continuous service for about 2 months, then defrosted, repacked, and cooled down for standby. The release occurred about 5 hours after the cooldown. This standby procedure was discontinued immediately. Several alternate methods were proposed, but we finally decided to keep the pumps cold with cold nitrogen gas, preferably waste nitrogen, from a convenient location. This was vented to the atmosphere through the drain valve. The process is shown in Figure 2.

We have recently had reason at one facility to want oxygen in the standby pump to minimize the time necessary to get the alternate pump into service to satisfy the customer. For the time being the pump liquid is being drained periodically, but we are inclined to shy away from this procedure because of the human element. Operators sometimes forget to complete this draining procedure.

We intend to modify the piping so that, after initial cooldown, a small flow of oxygen will be taken from the line upstream of the pump inlet valves and teed into the pump drain lines, filling the pump and discharging through a vaporizer and a rotameter from a point at the pump inlet downstream of the pump inlet valve. (See Figure 3.) The initial purge rate is to be set so that the liquid in the barrel will be completely changed every 8 hours without any concern for the volume of internal parts in this barrel. Since the pump and the pump case take up a good portion of this volume, the actual change is probably nearer to twice that of the liquid contained in the free space. At this rate, a pump barrel about 10 inches in diameter and 3 feet long only requires about a 3-scfm purge rate.

There is one question about this new procedure: Is the purge rate sufficient to keep liquid at the top of the pump, or will the heat influx vaporize more liquid than this purge rate will supply? With satisfactory insulation, there will probably be sufficient purge, but we are installing a valve where the purge outlet comes through the jacket so that we can check there for the presence of liquid. Incidentally, this vaporizer is to be cleaned at the same frequency as the pump, since it will obviously be a collector of contaminants.

So you can see that pump cleaning is critical. POM procedure 1.07 outlines the cleaning and sampling methods, and the cleaning frequencies are in 5.06. Here again, analysis of samples permitted us to reduce frequencies, but sampling methods and pertinent data were problems that took more time than should have been necessary. Initially, Aliquippa and similar process plants (Granite City 70 T/D and New Johnsonville 85 T/D) had their pumps cleaned at 6-month intervals and all other plants annually. As POM 5.08 indicates, plant is now on a yearly schedule, and the others are on 18 months and 2 years.

Sampling problems for pumps are essentially the same as plant problems. It is a matter of opinion as to which is more tedious. I believe that the pump accuracies are more difficult to achieve, since contaminant and solvent quantities are so small. For this reason, it is better to weigh the solvent if a scale is available. The highest contamination count we ever had was 44 grams, but the normal total contamination in plants built since 1960 has been nearer to just several grams. For effective surveillance of trends, we must also have a reasonable estimate of pump operating time. Analytical results are calculated and then the contamination rate is determined in grams per 1000 hours of operation. This gives us a unit of comparison for relating results. For plant washouts we figure the contamination rate in pounds per year.

Another cleaning consideration is time; pumps must be cleaned as quickly as practical. Permitting pumps to "soak" for several hours or overnight has no appreciable effect on the cleanliness of the completed job, but solvent evaporation will concentrate contaminants much the same as when cryogenic liquids "boil off." Use tricholorethylene, if available, because of its boiling point (188°), which is higher than that of methylene chloride (104°F). Chlorothene (162°-190°F) and perchlorethylene (250°F) are also recognized by our Safety Department as suitable for oxygen cleaning.

C. Desiccant Samples

Desiccant samples now require very little analysis. However, at least 3 years and a considerable amount of money were spent unnecessarily because information was not submitted with the samples, and desiccants were changed more frequently than necessary. Analysis work and records were started in 1960 but we could not get a significant basis for changing procedure until 1965. Meanwhile, we had, in 5 years, analyzed 286 samples (in many cases top, middle, and bottom of the same bed), and we had only 88 with satisfactory data (operating time, reactivation status, etc.) from which to draw conclusions. The results indicated that we were changing desiccants more often than necessary. Frequencies and reasons are now given in POM procedure 5.10.

All drier desiccant should be changed only in case of excess dust, moisture breakthrough, or oil on the downstream desiccant filter. The filters should be inspected at least every 6 months. Evidence of oil on the filters shall be reported to management, together with such details

that might affect the necessity for changing or sampling desiccant, or possibly even solvent washing the exchanger air circuit. It is reasonable to expect some slight indications of oil (particularly with a black light) on the inlet side of the filter, since dust may act as a carrier. However, oil on the filter outlet and piping would indicate a problem. Except for special reasons, there is no need to submit drier desiccant samples.

Carbon dioxide adsorbers too need only be changed where process problems occur. Oil in these units deters the adsorbent capacity and will cause carbon-dioxide breakthrough before it causes hydrocarbon contamination downstream of this point. After 57 months of operation, six samples from Aliquippa showed essentially no soluble contaminants, even on the top of the bed. Samples of the top desiccant should still be submitted with plant washout as a further check on this procedure, since the data was limited when we made the "no change" rule.

Oil adsorbers must be changed annually since they perform a rugged critical service. No sampling is necessary from these beds.

Hydrocarbon and guard adsorber desiccant beds must be changed every 5 years, and top and bottom samples should be submitted so we can test adsorbtive capacity. After sufficient information has been gathered and evaluated, we may be able to reduce this frequency. If the total hydrocarbons or acetylene in the pure liquid increase, thereby demanding more frequent adsorber desiccant changes, investigate thoroughly to determine whether environmental or process factors, rather than spent desiccant, are causing the increase.

Most of you know that desiccant dusting can be reduced considerably by carefully trained and monitored operators. A good example happened a few years ago at an E7000 (7 T/D) plant, relatively small by today's standards, which had gone 7 years without changing drier desiccant. I recall being contacted by our Safety Department as to whether I had seen the report and after stating their concern, I commented on the fact that analysis did not show any evidence of a problem and the matter was dropped. This was during our initial program of yearly changes. The incident does serve to show that proper changing and reactivation can save a lot of trouble and expense.

Again with desiccant change, inadequate information was submitted, and it took 5 years to accumulate a history which could have been done in 2 years. By 1965 we were using better than \$100,000 worth of desiccants in our plants; with the new change frequency, at least \$50,000 has been saved each year. With additional plants added to our organization since that time, the savings are still more significant. As long as we are dealing with figures here, I might also mention that the laboratory work alone for samples analyzed, but not considered, due to insufficient information on their operating histories, cost about \$5,000.

D. Plant Defrosts

Scheduled defrosting of plants will help remove hazardous contaminants as well as water vapors and carbon dioxide. There is also some continual removal of hazardous materials, since they are all soluble to some degree in the liquid products drained. Solubilities vary from methane, which is almost completely soluble (approximately 740,000 ppm) in oxygen, to acetylene (less than 5 ppm). However, there are areas where there is no liquid contact and areas where the liquid levels are held relatively stable so that there is some concentration at the liquid-gas interface on the vessels and pipes. There have been several minor reboiler explosions where inspection after the explosion revealed a "bath tub ring" of contaminants at the boiling surface level, where normal operation would stabilize the liquid level.

In processes that still use driers, the heavy hydrocarbons, including compressor oils and medium hydrocarbons such as pentane and hexane, are removed by the driers.

In theory, compounds that boil above 90°F and freeze above minus 270°F are trapped in the heat exchangers until they are defrosted. In practice, small quantities are undoubtedly carried further into the plant.

The only other means of contaminant removal further downstream is the hydrocarbon adsorbers and, in some cases, guard adsorbers. Fortunately, the silica gel in these vessels is very effective in removing acetylene and the lighter hydrocarbons $(C_3/)$. It is fairly effective with ethane and ethylene. Also, the silica gel removes organic compounds and virtually all inorganic compounds (including the oxides of nitrogen), except carbon monoxide.

Theoretically, methane is the only contaminant that can reach the reboiler after these process "traps," and fortunately it is the contaminant that is most soluble in oxygen. However, we all realize such trap systems are not completely effective, and fractions of the more hazardous compounds will also make their way to the reboiler area.

In 1965 and 1966 we did some research on gases vaporized and discharged during defrosts at seven of our plants at six different locations. Samples from five of the plants were considered reliable. A measured flow was passed through a vessel containing silica gel immersed in a container of solvent cooled with dry ice. Contaminants were later desorbed from the bed in our laboratories, and quantities were measured and then related to the estimated total flow through various circuits. Most of the work was with the compounds removed from the regenerator and column sump-condenser areas.

Sampling methods and flow measurements were quite crude, considering what we wanted to find out. However, we did find traces of acetylene in the condensers of two of the plants and minor amounts of hydrocarbons up through the C-7's. Methane was only found in one condenser, and the amount was negligible. Although this serves to show that methane can pass through all process obstacles it will drain with the products. Oxides of

nitrogen were found in all the plants. The Pittsburgh plants were obvious even withouth analysis. In the nitrogen-dioxide freezing range, a brown "smoke" was emitted from the regenerator outlets, with that acrid smell associated with those same oxides. Undoubtedly the proximity of the steel mill contributes to the contamination here.

It is not within the scope of this paper to discuss the properties of contaminants or engineering systems for their removal, but I did want you to be aware of some of the work we have done. There are some more details on these problems in the AICHE reports, "Safety in Air and Ammonia Plants," which are now in binders at all the plants and in other key spots throughout the Operations Department.

Plant defrost frequencies are spelled out in POM procedure 5.09. Government-owned, APCI-operated (GOCO) 75 T/D plants must be defrosted at least every three months. Although most of you are probably inclined to believe that this is too often, we have had three energy releases in the reboilers of these plants since 1964, and each release occurred about 4 months after a defrost. In each case, only one tube had failed, probably from being plugged by carbon dioxide and "dry boiling." We are now doing analytical work in this area to prevent furture releases.

Standard nitrogen plants are to be defrosted every year because of the relatively stagnant condition of the reboilers (there is no oxygen product drainoff of this point). There is a small continual safety drain plus a periodic drain to maintain the liquid levels by compensating for the excess refrigeration necessary to automate the plant.

All other plants are to be defrosted every 2 to 3 years, preferably scheduled shortly after 2, to allow a margin in case of postponements. We know that customer demands and relations sometimes create high on-stream requirements and consequent rescheduling.

E. Batch Sampling

Batch sampling at most plants is necessary primarily for quality control rather than for safety. However, since these samples are analyzed for oxides of nitrogen, methane, and total hydrocarbons, they are also a safety check. The details of this sampling are in POM section 2.03.01.

Normally, one sampler is to be submitted monthly for each product at a facility. Where there is more than one storage tank for a single product, alternate the samples. There have been submittal problems; some of these are our fault, and others, the Specialty Gases Department, where there are apparently manapower and instrument difficulties. At one time we did not have enough samplers, but there should now be two samplers for each product at each location. It may still be difficult to return samplers on time, but the fine records of Lathrop and Pinole Point, who send theirs all the way from California, seem to indicate that most samplers should be received on schedule. From some plants, we received only two of

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any one product in 1967. (To give credit where it is due, however, the Delaware City and Ashland plants also have good records.)

Samplers are coded by Specialty Gases for product usage: green for LOX, brown for LIN, and blue for LAR. The sampler should not be used for other than its coded service, since that makes cylinder cleaning and purging more difficult and analytical results often doubtful. We could probably deviate from this procedure in emergencies, but such a change should be cleared through myself.

General sampling instructions are supplied on the inside of the case. Be sure the sample stream is a steady flow of liquid before you close the sampling inlet and outlet valves. Then be sure to open the drain valve and drain out all the liquid before closing it, or the final pressure will be too high. However, don't keep the valve open too long, or the final pressure will be too low. After completing the sampling, allow the cylinder to warm to ambient temperature and check the pressure gage; the rupture discs are set for 1800 psig and the normal settled pressure will be 1200 to 1300 psig. If the settled pressure is too low, the sample was not taken correctly or you have a leak.

Leave the cylinder in an isolated safe area with a reasonably constant temperature for at least 24 hours before shipping. Check the gauge again and if the pressure doesn't seem to be holding, soap the fittings and repair the leaks. Do not make repairs with pressure on the cylinder. Oxygen sampler repairing shall be handled accordingly as far as cleanliness is concerned.

Rupture discs will only be replaced on nitrogen plant batch samplers. Quality control samplers on other plants are too critical for field repair. Contact the Operations Safety-Service Manager when you need a supply of discs. After repairs requiring opening of the cylinder, pressurize the sampler and bleed it down three times with the gas to be sampled before you take the liquid sample.

If the sample is taken properly, there should not be many rupture disc problems. I have had some complaints in that area, but it seems odd that 95 percent of these complaints are from two locations.

Use standard Straight Bill of Lading (Form 3102) for shipment, and mark it "DOT Special Permit No. 3302," which is the permit that allows us to ship gas of this type under pressure. Under DOT regulations, you must also attach the green "Nonflammable -- Compressed Gas" tag (Form 412-G) to the outside of the case. Be sure to write the name of the gas on that tag.

Fasten the I & M Quality Control Sample tag (Form BST-1) securely to the inside of the case. Be sure to fill in all the information on this tag and send a copy to me so I will know it has been shipped. I will record its shipment and will have this record to determine compliance with your plant requirements. Even if you only return the sampler for repairs, send me a copy of the tag, with the "Remarks" section marked "Returning for

repairs." Shipping details are given in POM procedure 2.03.01. Samplers are to be shipped prepaid and will be returned "freight collect."

Batch samples from our standard nitrogen plant condensers are taken strictly for safety. Sampling methods and shipping procedures are the same as for the other plants, but there are a few added requirements; these are given in POM procedure 1.15.

As with the other samples, we often do not receive adequate operating data from these plants. This information is especially important at present, because we are trying to determine safety requirements that will help us avoid another energy release like that at Pinole Point in January 1967. Since that release, we have added purge vaporizers to the old plants (they are part of the newer plants) and are trying to make "before and after" comparisons. We seem to be on the right track, but we need more statistics. To simplify submittal of this information, form 3617 was developed and is included in POM procedure 1.15. You now only have to fill in seven numbers and send a copy to me when you ship the sampler to Specialty Gases. I do not need a copy of the tag, as with Quality Control samplers. The form includes all necessary information.

With the nitrogen batch samplers we will normally require monthly samples for only the first 6 months; after that, assuming that we have a satisfactory history and compatible atmospheres at the site, samples can be submitted every 2 months. There is only one batch sampler at each nitrogen location, so there may be some problems submitting the monthly samples on time. However, I have recently purchased two samplers for floating assignments and you can request these from my office. If monthly samples have to be continued after 6 months, the facility should purchase another sampler of its own.

Both Specialty Gases and Research and Development analyze the nitrogen plant sample. Specialty Gases analyzes it for purity, carbon dioxide, and total hydrocarbons; R & D performs a complete breakdown of the hydrocarbon contents and acetylene. For this reason, it is important to fill out the I & M Quality Control Sample tag properly. In some cases where management personnel at the large facility take care of the nitrogen plants and then ship from the main facility, there have been cases when the main facility location instead of the nitrogen plant location was written on the tag, and the sampler was therefore not forwarded to R & D but treated as a regular quality control sample. So be sure to write the nitrogen plant location in the Plant Location section of the tag. In the Remarks section, write "Return this sampler to (applicable facility)." This will keep the sampler from being shipped to a customer location, where we only have men once of twice a week and the cylinders can get lost more easily.

The nitrogen plant batch samplers are coded green (for oxygen), since they normally are 60- to 70-percent oxygen. If they were coded for nitrogen, the analysts might put them through the nitrogen analyzer and run the instrument off scale, resulting in the necessity to repair it, or at least cause a delay until it settles out or is calibrated.

All of the nitrogen plant sampler analysis reports are surveyed and logged by me in a Kardex system. If the plant manager is not on the report distribution list, I see that he gets a copy. If there are any comments about the results, I make notes on the report and send copies to the plant manager and Jim West. Our main concern is magnitude of hydrocarbon contamination and of acetylene and carbon dioxide content. There seems to be a correlation between these contaminants, and present purge requirements shall be maintained to keep the carbon dioxide content below the 5-ppm solubility level for this condenser liquid. Operating procedures are presently set at a purge rate equivalent to 0.5 percent of the total air feed. It appears that this will be satisfactory, but we need more samplers and information from you.

3. OPERATIONS DEPARTMENT PUBLICATIONS

Finally, I would like to talk about our Plant Operations Manual (POM), its history and its purpose. Plans for this manual were initiated in May of 1967. The preliminary contents were established and persons were assigned to write about topics within the scope of their responsibilities and specialties so that others could learn from their techniques and experience.

The need for the manual is obvious. The continual growth of the Operations Department demands a formal distribution and a general collection center for procedures, which are otherwise often forgotten or lost in the files. The manual is also used as a training guide, to introduce the Department's operating and safety practices to the increasing number of new and transferred personnel.

Almost all plants have two of these manuals designated POM and POMC. The POMC is the control room copy and contains only the first three sections: Safety, Product Quality and Handling, and Plant Operations. The POM is the management copy and also contains sections 4 through 7: Budgets and Costs, Administration, Maintenance, and Interim Operating Procedures. These sections concern only management functions, with the possible exception of some of the maintenance information.

As you know, when we send you additions to the manual, the receipt must be signed and returned so we know that you have received them, and that you acted accordingly on adding them to your manual or substituting revisions, as the case may be. There are more than 90 of these manuals issued now, and follow-up calls and memos put an unnecessary load on our office staff, so please send your acknowledgements as soon as possible.

Some people have been reluctant to sign these acknowledgements because the procedures state that it is necessary to understand and comply with them. I want to point out that it says "understand" or "be familiar with its contents." It does not mean that you are expected to memorize them. We only want to know that you have the procedure and can refer to it as necessary. We assume that you will become thoroughly familiar with those particular procedures that affect you daily or frequently.

There are two Safety binders at each plant, both of which should be available to all plant personnel. One of these contains all the Safety Grams issued by our corporate Safety Department as well as miscellaneous safety papers. Quite soon the Safety Bulletins will also be issued as a separate section of this binder. Only those bulletins that are still relevant will be included; some have been deleted because they concern what is now accepted practice, like wearing hard hats and safety glasses, and others have been superseded by other manuals or letters. A full list of all 20 bulletins issued since 1959 will accompany the bulletings, including reasons for those deleted. Where we now have other material elsewhere of a more detailed nature on the same subject, we will reference these sources. Remember that these bulletins are usually an interim means of sending personnel important safety messages, and directives on the same subject that follow the bulletins will take precedence.

Our other safety binder contains the AICHE symposium manuals entitled "Safety in Air and Ammonia Plants," which are issued annually. Volume 9 was distributed just a few months ago. For those of you who do not have volumes 1, 4, or 5 in your collection, don't worry about it. They are no longer in print.

The manuals are issued to a plant, not to a person, and although you are responsible for that manual while at a plant, the manual should remain there if you are transferred. If you go to another Operations location, there should be a manual there left by the former manager. If you go to a new plant, and there is no manual there, notify us and we will send you one.

We hope that the manual will increase the efficiency of your operations and that you will contribute anything that would help the other plants and supervisors. The manual is our way to spread feedback information so managers can benefit by each others' experiences.

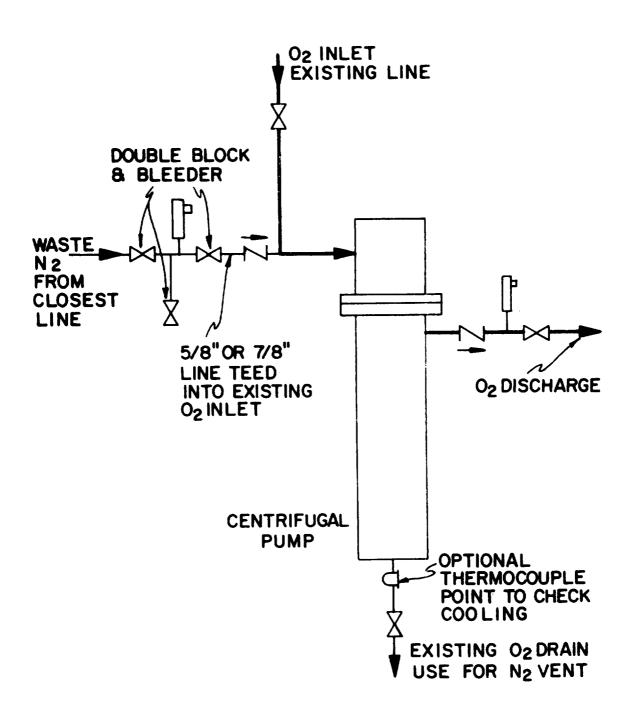
4. SUMMARY

To conclude, I would like to summarize the points I have tried to make:

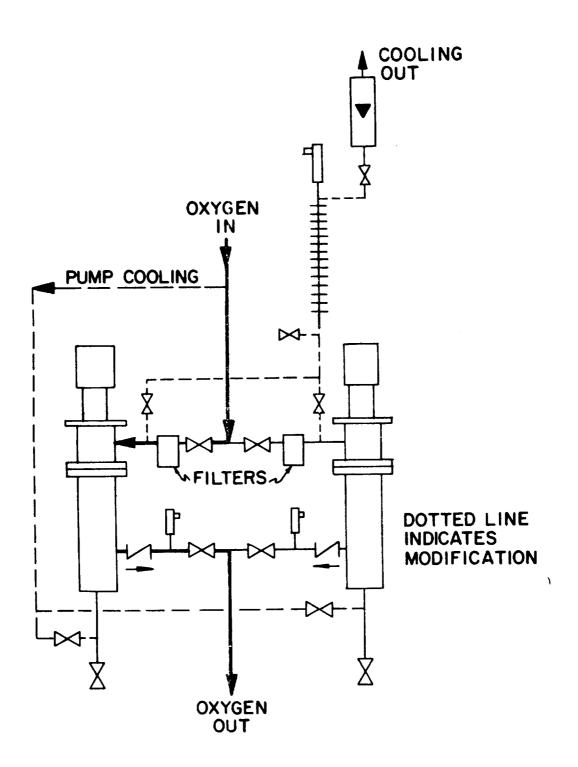
- 1. Samples and data are recorded and reviewed periodically in an attempt to make your job easier, APCI profits higher, and accidents less frequent. Above all, remember that samples are useless without supporting information.
- 2. To ensure safe operation of our plants, we must accrue analytical results from which to determine preventive action and justify the expense.
- 3. Only you can supply the information we need. Our prompt response to your problems depends on our having everyone's cooperation.

- 4. It is our job in the home office to interpret your efforts, help you in any way we can, and see that operations are made more efficient by this interaction. Although today I talked specifically about contamination histories and remedies, we are of course available for help in any area.
- 5. The new manual is your manual. Help us to improve it for you by contributing to its contents or letting us know what is missing.

PUMP STANDBY COOLING PIPING WITH NITROGEN



PUMP STANDBY COOLING PIPING WITH OXYGEN



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CRYOGENIC SYSTEMS DIVISION PLANT OPERATIONS MANUAL

Supersedes 5/23/69

EXCHANGER, PLANT, and PLANT EQUIPMENT SOLVENT WASHOUT FREQUENCIES

I. PURPOSE

To establish a standard procedure to advise Operations Department personnel of exchanger, plant, and plant equipment solvent washout frequencies.

II. RESPONSIBILITY

Plant Managers and Maintenance Superintendents are responsible for compliance with the provisions of this procedure as applicable.

III. PROCEDURE

A. Scope

The frequencies listed are for <u>normal</u> operations. Process or equipment malfunctions which may contribute to contamination must be investigated. If necessary, the circuitry involved or the complete plant shall be solvent washed. All such incidents shall be reported to the Regional and Operations offices.

No frequency is listed for low-pressure plants with nonlubricated centrifugal compressors. No contamination is expected under normal operating conditions. Abnormal conditions or equipment malfunction (such as expander seal gas failure) may prompt action in this area. If any such problems are suspected, they shall be reported to the Regional and Operations offices. There are several exceptions to this ruling. Oxygen vaporizers, liquid dump tanks, and defrost stacks which have oxygen connections are to be cleaned every 5 years. Details are given in III., B., below.

B. General

These frequencies are based, for the most part, on a review of solvent analysis made on washouts from the various plants. They are also based on a study of the individual plant and basic design process operating histories. Solvent samples shall be taken on all washouts. Accurate sampling and subsequent analysis may indicate that a change of frequency can be made. See section 1.05 for details and sampling methods.



PLANT OPERATIONS MANUAL

Supersedes 5/23/69

EXCHANGER, PLANT, AND PLANT EQUIPMENT SOLVENT WASHOUT FREQUENCIES

Plant "dump" tanks, vaporizers, and vent (defrost) stacks with oxygen-rich connections are to be cleaned as a part of the plant washout on all plants, as applicable. Five years will be the maximum interval for these items, should future schedules extend beyond that interval.

Oxygen product vaporizers shall also be cleaned at the same frequency as the scheduled plant washout, but never less than every 5 years. Since this vaporizer is usually used to supply the customer during a plant outage for a scheduled washout, the vaporizer can be cleaned either before the plant shutdown or after the plant is back on stream and the solvent and cleaning equipment are available.

Those plants with vapor dispersal systems in their loading areas shall clean their associated "dump" tanks every 5 years.

FREQUENCY - YEARS

Facility-Plant	Exchanger Air Circuit	Exchanger Oxygen Circuit	Complete Plant
Allegheny	-	-	10
Burns Harbor	10	10	*
Cleveland Plants #1 & #2	10	10	*
Delaware City	-	-	10
Granite City 170 T/D	10	10	*
Kenova	2-1/2	-	5
New Johnsonville 85 T/D	-	2	4
Pittsburgh	10	10	*
Sparrows Point Plant #1	10	10	*
Weirton Plants #1 & #2	10	10	*

^{*} Analytical results of exchanger solvents are to be evaluated to determine necessity, if any, for plant cleaning at a future date.



CRYOGENIC SYSTEMS DIVISION PLANT OPERATIONS MANUAL

SECTION 5.07

PAGE 3 OF 3

DATE 7/15/70

Supersedes 5/23/69

EXCHANGER, PLANT, AND PLANT EQUIPMENT SOLVENT WASHOUT FREQUENCIES

IV. RELATED PROCEDURES

1.05 PLANT SOLVENT WASHOUT - GENERAL1.11 SAFETY TESTING SCHEDULE FOR OPERATIONS PLANTS

V. RELATED FORMS

3554 Rev. 3, 2/67 PLANT SOLVENT WASHOUT REPORT



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 1 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

I. PURPOSE

To establish a standard procedure for conveying to Operations Department personnel the general miscellaneous information that will promote safe, expeditious solvent cleaning of plant circuitry when used as advance study material in preparing for these plant washouts or as a supplement to specific plant solvent washing procedures.

II. RESPONSIBILITY

Plant Managers, Maintenance Superintendents, and operating personnel are responsible for compliance with the provisions of this procedure as they apply to specific equipment with which they are concerned.

III. PROCEDURE

- A. Preliminaries The following steps can be taken before or during defrost to reduce downtime. Apply as necessary to the individual plant.
 - 1. Dig into the noncondensable valve if the procedure calls for pressurizing the low- or high-pressure columns.
 - 2. Dig into pumps, pump filters, hydrocarbon adsorbers, CO₂ adsorbers, check valves, etc.
 - 3. Obtain a blank sample of solvent to be used.
 - 4. Gaskets and blanks can be made where applicable.
 - 5. Some adapters, hoses, etc., can be attached to proper outlets to save time during cleaning.
- B. Washout The following are a few hints from past experience. Apply them as necessary.
 - 1. Although experience has proved that recirculation is not entirely necessary for a thorough cleaning, provided that solvent is allowed to remain in the system for a minimum of linear, it is desirable wherever the washout piping is not too complicated to make it practical. In many cases, the drain point will be reasonably close to the introduction point. Recirculate in such instances. New solvent should be introduced until it comes from the drain hoses and fills a reservoir with 20 or 25 galless. At this time the pump suction hose should be



PLANT OPERATIONS MANUAL

SECTION 1.05

PAGE 2 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

removed from the clean solvent source and put into the drained solvent. If this first solvent is excessively dirty, pump until clear solvent emerges from the drain hoses, then set aside the dirty solvent. Add enough clear solvent to the reservoir to replace the amount set aside before starting recirculation. Remember to include the dirty solvent in your sampling by putting it in a drum of other solvent which is <u>finally</u> drained from this same circuit. Use common sense in determining recirculating time by considering circuit volume and pump capacity. Solvent should be recirculated at least three times and in no case less than 1/2 hour.

- 2. Be careful when pumping into excessively hot circuits. Pressure buildup from vaporizing can ruin the pump. This is one reason for installing the check valve and pressure gauge as illustrated under "Pumps".
- 3. When the plant is not operating, liquid-level gauges will not always indicate. To determine the level of solvent at any point, a nitrogen back-bubbler will be necessary. This is accomplished by putting a slight nitrogen bleed, from a cylinder through a regulator, into the lower liquid-level vent valve. Then as liquid builds up in the vessel, the pressure required for this bleed through the liquid will be indicated on the gauge. Naturally, the high- and low-pressure shutoff valves must be open and the bypass and upper liquid-level vent valves must be closed. Where transmitters are used they should be disconnected at the jacket and a separate Barton instrument hooked up temporarily at this point. Remember to consider the specific gravity of the solvent used, since most of these instruments are calibrated in inches of water. Methylene chloride (s.g. 1.326) will indicate about 4 inches for approximately 3 inches of actual level.
- 4. Eafer to the Safety Manual or consult your supervisor on protective equipment to be worn and precautions to be taken when handling solvent.
- 5. It is usually better to start with all valves on the plant closed, then open them as required. This reduces the possibility of operator error, which may permit solvent to enter undesirable areas.
- 6. When several plants tee into a common product line, air circuit, etc., it is necessary to install planks in flanges rather than to depend on a valve, which may leak solvent from the plant being cleaned to operating lines of the other plant.



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

SECTION 1.05

PAGE 3 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

- 7. Do not depend on shutoff valves to stop flow to instruments, gauges, analyzers, etc., which may be ruined by the solvent. Close the valve and disconnect the line downstream of it. This will not be lost time, since these circuits must all be blown clear in the final defrost anyway.
- 8. Clean, dry air or nitrogen may be used to pressurize vessels and/or to blow most of the solvent out immediately after cleaning. It is important to get out as much solvent at this time to minimize residues left by evaporated solvent, to get a truer representative sample of drained solvent, to prevent excessively prolonged vapor emission during a final blowout and to reduce the possibility of plugging caused by heat transfer from cold insulation.
- 9. In some plants, the circuitry makes it possible to route the reactivation blower (or blowers) discharge flows back into many parts of the plant for pressurizing or blowing out the solvent. It is usually done by opening the reactivation inlet line on the drier or hydrocarbon adsorber and the process valve into or out of that same vessel depending on the area to be blown. In some cases, it may be necessary to open a flange or pull a valve bonnet for blower suction.
- 10. Be sure to clean defrost stacks, drain lines, dump vaporizers, and dump tanks as part of a plant washout. There have been at least two instances in the industry where men were injured when opening cold valves into defrost or drain stacks and had reactions which could only have been caused by contaminated circuits and thermal shock or sudden flow changes into the warm lines.
- C. Defrosting Prior to Washout It is important to get the plant warm, but excessive heat can also increase downtime. If the plant is too warm, rapid vaporization of the solvent as it enters will delay circulation of liquid through the entire circuit until it has been cooled down. Know your solvent properties beforehand and refer to the thermocouples to determine when to stop the defrost.

Since the insulation will remain cold, and since neat transfer after defrost shutdown could cause freezing of the solvent in the line, it is a good idea to get the plant as warm as possible, keep it that way for a minimum of 12 nours (maximum of 24 hours), and then shut off the neater for the last 2 to 4 hours (depending on plant size). It is preferable to defrost longer than may be necessary to insure that solvent does not freeze in the lines.



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 4 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

- D. Materials The following materials should be on hand before actual defrost and washout so that downtime can be kept to a minimum. Apply as necessary, depending on size and type of plant.
 - 1. Pumps, hoses, tubing, and fittings as mentioned above.
 - 2. Sufficient solvent.
 - 3. Nitrogen cylinders for blowout and pressurizing.
 - 4. Pump reservoir for recirculating. A 55-gallon drum cut in half will do the job. Clean drums for draining and obtaining samples.
 - 5. Packing for all cold valves and all valves (warm or cold) in oxygen service. Packing hooks for packing removal.
 - 6. Empty tanker, tanker compartment, or adequate supply of drums for waste solvent.
 - 7. Sample cans.
 - 8. For regenerator plants, a suitable device for spraying over the regenerator bed, if this is to be done. A lawn sprinkler with adjustable rotating spray heads will do an excellent job. It may be necessary to remove the restricting nozzles to get an adequate flow of solvent.
 - 9. A meter for measuring the solvent introduced into each circuit. This is not necessary if drums are used but could help in speeding up operations. Meter construction must be suitable for solvent service. If a tanker is used, a capacity curve for each compartment should be requested from the vendor so that quantities used or drained can be determined. This should apply only to circuits where relatively large quantities of solvent are used (over 200 gallons), since it is not completely accurate. Smaller circuits should have the solvent measured by a meter or should be drained into drums for measurement, then pumped into the plant.
 - 10. Desiccants, if they are to be changed.
 - 11. Personnel safety equipment, such as chemical goggles, rubber gloves, etc., should be on hand. Refer to the Safety Manual for details.
- E. Pumps For the larger plants, pumps should be capable of pumping at least 10 GPM against an 80-foot head. In many cases, depending on plant size, a 20-GPM would be more desirable. Pump materials of construction must be compatible with solvents. A gear pump is preferable, and should have an



PAGE 5 OF 12

DATE 2/20/67

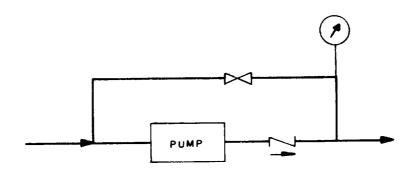
Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

internal bypass. We have had excellent service from the Oberdorfer pump, which is bronze with stainless steel shafts and bronze or carbon bearings. If there is any problem ordering satisfactory pumps in individual areas, they can be ordered from W. W. Grainger, Inc., 723 E. Green Street, Allentown, Pa. The following specifications and performance data apply to these pumps when operated at 50 psi and 1725 RPM. There are about 70 Grainger outlets in major cities throughout the U. S., most of which stock this item.

Grainger Cat.No.	Mfg. No.	Pipe	Shaft	Wt.	List	<u>GPM</u>	HP
1P376 1P377	4000R 7 000R	1/2 3/4	5/8 5/8	8 10	35.75 47.75	9 - 1/2 19	1 2
1P378	9000R	1	5/8	11	50.75	22	2

To use these pumps to full advantage, they can be piped as illustrated below. With this setup, the manual bypass can be adjusted, if necessary, when pumping into small tubing or when heat vaporizes the solvent during the initial charge. This piping can also be used to start a siphon action to drain vessels that have a warmup loop which would otherwise require pressurizing to drain the liquid. To start the siphon action, run the pump for a short period to fill the line, stop the pump, immediately open the manual bypass, and put the suction line into the vessel intended for drained solvent. The bypass valve can also be used for draining from the same outlet through which the solvent is introduced by transferring the suction line to a drain drum and opening the valve.



F. Hoses and Piping - Flexible metal hoses have been the most efficient means for making quick connections during washout procedures. Although they are quite expensive (approximately \$5/ft. for 1 inch), they are durable, and the cost is not prohibitive when the time required for copper or



PAGE 6 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

rigid pipe hookup is considered. It is recommended that the corrugated (bellows type) hose with the braided wire exterior be ordered for maximum serviceability.

Never use rubber or plastic hoses with solvents. Teflon or nylon hose can be used with chlorinated hydrocarbons, but Teflon hose is at least twice as expensive as metal, and nylon, to our knowledge, is not available in any size over 7/16" 0.D.

American Hose, Type S-1 with Type SM ends and Flexonics hoses have been used with success. The former is available through the American Brass Co., Metal Hose Division, Philadelphia, Pa., and the latter from R. Casper Swaney, P. O. Box 272, Carlisle, Pa. These hoses, too, are available in major cities throughout the U. S.

In addition to the flexible hose connections, some extensive runs may be necessary for certain washout procedures. In these cases, straight runs of pipe can be made during defrost operations and final hookup completed at each end of the rigid pipe with flexible hose. In many cases, it may be possible to leave this pipe in place for future work. For example, on split cycle plants we have run rigid pipe from the ground level to the tops of the regenerators for flushing the regenerator stones with solvent.

It is also advisable to have coils of small copper tubing (1/4" to 5/8") to use at various points to drain into the drums.

G. Fittings - Required fittings can be expedited by checking through the washout procedure beforehand. It is advisable to purchase brass fittings so they will not rust and to store them separately so they will be available when necessary. These fittings should include any adapters required to make a connection to the flexible hoses, compression or flare fittings for copper tubing drains, and hose connections where it may be necessary to pressurize or blow out with a nitrogen cylinder and a regulator. In many cases, it may be possible to leave these fittings on valves, etc., so that they can be used with each cleaning.

A good supply of unions sized for the flexible hoses should be on hand. In this manner, the next circuit can be fitted while one is being pumped or recirculated, and the switch can be made rapidly by disconnecting one and applying it to the next. Unions at each end of the hoses permit faster connections when more than one length of hose is required. Be sure all the unions are made by the same manufacturer so they will be interchangeable.



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 7 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

H. Solvents - Methylene chloride is to be used for washing plants. Because of its high vapor pressure and low boiling point, it is easy to remove during blowout and defrost. In addition, its low freezing point is desirable if there are still some cold spots within the plant when the solvent is introduced.

Properties of this solvent are outlined below:

Solvent	Formula	Boil Pt.	Freeze Pt.	Vapor Press. mmHg.	Specific Gravity	Approx. Cost Per Gallon
Methylene Chloride	CH ₂ Cl ₂	103.6	-142.1	355	1.326	1.74

When ordering, specify inhibited grades of solvent to prevent acidic action on metals where water or water vapors are present. Also, specify for metal cleaning of equipment in oxygen service and that the maximum residue permitted on evaporation is 0.001% by weight. When drums of solvent are ordered, it is good to specify that all be from the same lot number. This will permit easier and more accurate sampling.

For further information on handling, refer to the Vendors' Literature, the pocket sized Operations Safety Manual and the Safety Standards.

In many cases, it will be more economical and convenient to order solvent by the tanker load. If possible, a waste solvent tank or tanker compartment should also be on hand to store used solvent. This waste solvent can usually be resold to the vendor or to other firms for redistillation. When a tanker is ordered, be sure to obtain a calibration curve for each compartment, so that quantities used or drained can be measured. See "Sampling" for more details.

I. Sampling Solvents - One quart samples for analysis are required to determine the magnitude of contamination. Analysis can be made locally or submitted to our R&D Department. When submitted to our R&D Department, be sure to issue a Work Order and a copy of the Plant Solvent Washout Report (Form 3554) to them.

Use common sense when obtaining representative samples.

Samples must be taken of unused solvent ("blank" or reference samples) for comparison. When a single tanker or drums of the same lot number are not used, a separate "blank" sample must be obtained and related to the circuit or circuits in which it is used.



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 8 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

Solvent samples are to be representative of all solvent drained, not only of the initial discharge. In some cases, the solvent will be recirculated and a sample can be taken from the recirculating reservoir near the end of the cycle. When draining into drums and more than one drum is used, obtain equal quantities from each drum, pour them collectively into a clean container, mix thoroughly, and then obtain the one quart sample from that container. If there is a fraction of one drum drained, that fractional portion would be put in the collective container. Example: Two and one-half drums are drained. Then equal portions would be put in the collective container from each of the full drums and one-half as much from the half-filled drum. A quart sample would then be drawn after mixing.

When a tanker of solvent is used, try to get a 3-compartment trailer with enough solvent in one compartment for the low-pressure column and condenser, the remaining required solvent in another compartment and a third empty, clean compartment. The low-pressure column and condenser are usually washed first. Simply take a sample of the compartment, then pump it into the circuit, allow to stand, drain it back into the same compartment, then agitate it and take a sample of the total draining. When reusing this solvent for other circuits, this final sample will be the reference for these other circuits. One of the other circuits cleaned with this used solvent will probably be the high-pressure column, which will normally require over 200 gallons in the larger plants. This solvent can then be drained into the clean, empty compartment, agitated, and the circuit sample obtained.

Samples are almost useless if the quantities of solvents used in the circuit are not known. Analysis is made by evaporating a known quantity of the used solvent and a known quantity of clean solvent. The weights of the two residues are then compared, and the amount of contamination in a gallon of used solvent is determined. This, in turn, is multiplied by the gallons introduced into that particular circuit, and the results indicate total contamination.

Sample cans must be clean before filling. It is a good idea to rinse them with solvent regardless of what you believe their condition to be. Paint cans are excellent containers. If cans with gasketed lids are used, the gasket material must not be soluble in the solvent, and the gaskets and lids should be soaked in solvent before using the can for the actual sample or the analysis will not be accurate. The gasket can also be replaced with Teflon, Garlock, aluminum foil, or some other material which will not be affected by the solvent but will still provide an airtight seal.



SECTION _1.05 PAGE_9 OF _12 DATE _2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

Usually these solvents can be sent to the home office only by Railway Express and only four 1-quart samples in any one package are acceptable. Leave a vapor space in the top of the can when filling and mark the cartons "THIS SIDE UP". Check with the local Express office, since we have found that the rules vary with locations.

Form 3554 lists pertinent data which should be submitted with the samples. This form shall always be filled out when any portion of a plant is solvent cleaned.

J. Sampling Desiccants - When desiccants are changed, samples should be taken from the top, middle, and bottom. If the desiccant is not changed, the condition may be checked by obtaining samples from the top and bottom. It is best to obtain these samples after a maximum heating cycle, but in any case the on-stream or reactivation time shall be recorded on the Plant Desiccant Sample Report (Form 3553).

K. Defrost Solvent Blowout

- 1. A flowsheet should be used to mark off the circuits and valves as the valve changes are made. Defrost, PT, and instrument outlets shall be marked as they are checked for flow and freedom from solvent. Use a colored pencil on all circuits checked and valve changes made. Be sure to put full flow through each bypass circuit at some time during defrost. Be especially careful when checking liquid-level and pressure gauge lines for flow. After having worked completely through the process, repeat the procedure as many times as possible until the defrost is completed. Different colors or cross-hatching can be used on repeated work.
- 2. When regenerators are washed, the check valves should be swung out during the initial defrost period and the cage assemblies removed from the spool pieces. Then replace the spool piece and reverse flow from the high-pressure column back through the regenerators and out the nitrogen stack. When the regenerators are cleared of solvent, the checks shall be reassembled, installed, and normal defrost continued.
- 3. When most of the solvent has been blown clear, the defrost should be stopped and all safety valves removed. Since it is possible to trap solvent in the static warmup loops to these valves, it is necessary to blow them separately to prevent solvent freezing in these lines, rendering these valves ineffective during normal operation. Air flow to the plant should be shut off intermittently until the plant is completely depressurized, then flow to the plant should be resumed. This will permit the solvent to settle and then be blown clear.



PAGE 10 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

Repeat as often as necessary until there is no indication of solvent being blown from these outlets, then replace safety valves.

- 4. While safety valves are being removed and installed, all cold valves and oxygen service valves shall be unpacked. After resumption of normal defrost procedures, these valves shall then be checked for flow from the packing gland area. Low-pressure or backseating valves can be repacked (after they are free of solvent) during the defrost. The remaining valves can be repacked before putting the plant on expansion.
- 5. During defrost, blanks which had been installed shall be loosened at the flanges, applicable valves opened, and lines blown clear of solvent. Stand clear of the flange when the valves are opened and take precautions to prevent blowing solvent into undesirable areas (expanders, rotameters, etc.,) or on personnel. After the line is dry, the blank can be removed and the flange reassembled for operation.
- 6. Silica gel will break up almost immediately if solvent contacts it. When beds containing this desiccant are not drained DO NOT DEPEND ON VALVES to prevent contamination. These vessels shall be pressurized above pump pressure whenever work is done upstream or downstream. Use a dry, oil-free, air or nitrogen cylinder with a regulator to hold a constant pressure. Vessels can usually be pressurized through a gauge or safety valve jacket fitting. If there is any doubt whatsoever that solvent has flooded any portion of the bed, it must be changed. Before solvent cleaning, pressurize the vessels, shut off the pressurizing source, and check for radical leakage. If leakage is serious, valves must be repaired before proceeding with cleaning.
- 7. CO2 adsorbers, hydrocarbon adsorbers, oil filters, and driers should be reactivated during defrost to remove any solvent or moisture which may have leaked into the beds. Since it may be necessary to use air for reactivation, it will be necessary only to heat to temperatures adequate for removal of the solvent which was used. If new desiccant was installed, full reactivation temperatures can be attained, since there is no danger of contaminants in the bed.
- 8. Only dry, oil-free, air or nitrogen is to be used for blowing and defrosting of oxygen pump inlet and discharge lines.
- 9. A halogen leak detector can be used to check for solvent traces while defrosting. Circuits which indicate solvent should be opened wide.

 Others can be reduced to a minimum flow.



SECTION 1.05

PAGE 11 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

10. After the defrost is complete, the plant should be put on cooldown to condense any solvent vapors which may be in isolated areas. Some judgment must be used in this area as the entire plant must be somewhat colder than the condensing temperature of the solvent. Thermocouples in the air from the exchangers should be taken down to at least -100°F. After attaining these temperatures, get back on defrost and heat up all areas to at least 10°F above the boiling point of the solvent before going back on final cooldown.

This intermediate cooldown is not necessary on exchanger washouts unless some valve leakage is experienced and appreciable quantities of solvent have gotten into other areas of the plant.

L. Final Details

- 1. Pressure test lines which were disconnected. This may be possible during defrost or during initial cooldown.
- 2. Reassemble and repack lines and vessels where necessary.
- 3. During cooldown, it will be necessary occasionally to blow defrost valves, pressure tap valves, liquid-level vents, etc., to check for solvent. Liquid level-lines, since they usually come directly from the bottom of the vessel, are especially critical. This is especially important when approaching the condensation temperature of the solvent used.
- 4. If a halogen leak detector is available, it can also be used to check for solvent when the plant is on expansion and the temperature is between the condensing and freezing points of the solvent. Usually, if solvent is indicated after reaching the condensing temperature, that circuit can be kept open and blown clear before reaching the freezing point.
- M. Washout Procedures Specific procedures have been compiled for most plants and are a part of this manual. These procedures are intended as a guide. They will get the job done, but experience may prove that there is a better way to do it. If full consideration to the process and safety aspects are given to the different method, use it. It is requested that such information be given to the Operations Safety and Service Manager so that the procedure can be revised.

Additional copies of these procedures are available for use during plant washout.



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 12 OF 12

DATE 2/20/67

Supersedes 1021 Dec. 6, 1963

PLANT SOLVENT WASHOUT - GENERAL

IV. RELATED PROCEDURES

1.05.01	Aliquippa 115 T/D Washout
1.05.02	Allegheny 80 T/D Washout
1.05.03	Chicago 69 T/D Washout
1.05.04	Clairton 34 T/D Washout
1.05.05	Granite City 70 T/D Washout
1.05.06	New Johnsonville 85 T/D Washout
1.05.07	Kenova 20,000 SCFH N ₂ Washout
1.05.08	Delaware City High-Pressure Air Circuit Washout
1.05.09	25 T/D Standard Plant Washout (Aliquippa and New
	Johnsonville)
1.05.10	Burns Harbor Exchanger Circuit Washout

V. RELATED FORMS

3553, Rev. 3, 2/67 - Plant Desiccant Sample Report (Exhibit A)

3554, Rev. 3, 2/67 - Plant Solvent Washout Report (Exhibit B)



PLANT DESICCANT SAMPLE REPORT

Location	Plant Capacity	Serial #
Wessel Sampled:Drier	dydrocarbon AdsOil Ads	CO ₂ AdsOther
Time Sampled Bed Has Beer	n In Service: MonthsAverage	Plant Onstream Time
Desiccant Charge (Type,Q	uantity,Bed Arrangement)	
Top #1 (A) Middle #1 (A) Bottom #1 (A) Top #2 (B) Middle #2 (B) Bottom #2 (B) Sample should be taken in Vessel Cycle Time Hrs Indor and Type Lube Oils Used: Lubricat	m Check If Reactivated Beling* Before Sampling* Wei	

Remarks:

Note: Refer to Plant Operations Manual, Section 1.05 for sampling techniques. Submit one quart samples in clean, air tight, non-adsorbent containers, preferably metal.

Copies of this report to Regional Office, Safety Dept., Operations Dept. Office, and R & D with samples.



PLANT SOLVENT WASHOUT REPORT

Location	on		Plant Capacity		_ Serial #	
				Scheduled		
Reason	for wash	out (if unschedule	ed)			
List de	esiccants	changed during ti	his wash			
If any	of the ab	oove desiccants we	ere changed sind	ce the last washout r	eport was s	submitted, give
		****	·			
Previou	us was hout	date	Exchanger	Plant		other
				onstream time since		
		ts since last was				
Plant _	Ex	changers]	Individual Exch.	. (where applicable) A	AB	C D
Sample	Number	Circuit and Bri	ef Description	of Method Introd	Solvent duced	Quantity Draine
Informa report.	tion below	v can be filled i	n by individual	s on distribution aft	er receivin	ng the analysis
Sample !	Number	Grams/Liter	Total Conta (Based on amoun		Type Cont	taminants
Note: F	Refer to F quart samp	Plant Operations Notes in clean, met	Manual, Section tal containers.	1.05, for sampling to Lid gaskets must be	echniques. compatible	Submit one with solven
(Copies of Office and	this report to ReRER & D with sampl	egional Office, Les.	Safety Department, Op	perations D	epartment

PUT IT IN WRITING

		Date	November 28, 1961
TO	G. Rubens	SUBJECT	Ignition Tests of "T" Film
FROM	E. Kehat		and Penton
ce:	Ball, L. Geist, J. McKinley, C. Stolz, J.		

"T" Film

The "T" film thread compound is a suspension of powdered Teflon in a carrier that was supposedly only water but had a strong sharp odor. When dried by exposure to air a cracked cake resulted. A microscopic examination showed that the cracks extend through the whole thickness of the cake. The Teflon particles are homogeneous and the cake was very smooth.

An infrared analysis of this material, to check for organic materials in the mixtures, will be made next week.

Six ignition bombs were used. "T" film compound was brushed on the surface of the bombs and oxygen was used at 2000 psig. No signs of ignition were found in any of the tests. However, the surface of the brass in contact with the "T" film was blackened and the "T" film had the blue-black tinge of copper oxides.

It was assumed that the "T" film mixture caused corrosion of the brass. Two further tests were made on this phenomenon.

- 1. A fresh brass surface was coated with the "T" film compound and left overnight in air. No signs of corrosion were found.
- 2. The surface of a clean ignition bomb was brushed with the "T" film compound. Oxygen at 2000 psig was introduced to the bomb and left overnight. Corrosion of the bomb was similar to those used in the ignition tests.

Penton

This material is used as seat material in CO_2 regulators. It was evaluated for use in acetylene and oxygen regulators.

Two samples of valve seats were soaked in acetone overnight and dried. A slight mass increase was noted but no swelling. The mass went down slowly as some of the absorbed acetone evaporated. After 3 days the mass of the valve seat was still about 0.3% greater than that of the original material. Microscopic observation showed that slight flaking of the rougher parts of the surface occurred. The extent of the flaking was small and does not disqualify the material for use in acetone.

A clean lathe was used to turn shavings of "Penton" for use in the ignition bomb. About 0.35 gm Penton and oxygen at 2000 psig were used. Six tests were made. In one test the ignition wire broke and did not operate. In the other five tests instantaneous explosion occurred with pressure rising to over 4000 psig and the Teflon seals on the ignition bombs blowing out with a flash of fire.

ORIGINAL SIGNED BY.

E. Kehat

EK:faj

230.15 CLEANING

230.15.1 The interior of all pipe shall be sandblast cleaned in place by the Klean-Kote method, P. O. Box 448, La Porte, Texas.

The pipe shall be blown out with dry, oil-free air or nitrogen after it is blast cleaned.

Cleanliness shall be judged in accordance with the method outlined in ASTM Designation D2200-63T. The cleaning shall meet the requirements as defined by this ASTM Designation under Preparation Grades Blast Cleaning Sa3. Pipe shall be inspected wherever accessible. With this method of cleaning, the Contractor shall supply pipe with no interior varnish.

- The interior of the pipe shall be free of all foreign matter such as scale, rust, or oil, and wipings shall be taken of pipe sections with a clean white rag. The wipings are to be examined for fluorescence under black light. Additional cleanings may be required if wipings fluoresce. The Contractor shall take the necessary precautions to insure that the interior of the pipe remains clean until installed and tested.
- 230.15.3 The Air Products and Chemicals, Inc. Representative shall be responsible for the inspection precedure and final determination of the cleanliness of the pipelines.
- 230.15.4 Contractor shall be responsible for supply of all temporary spool pieces and for temporary or permanent detail modification of pipelines as required at cleaning stations to permit specified in-place cleaning. Dimensioned installation sketches of such pipeline modifications shall be presented to the Air Products and Chemicals, Inc. Representative for approval.

230.16 INSPECTION

In addition to any code inspection, all fabrication and material shall be subject to inspection by a representative of Air Products and Chemicals, Inc. Approval of fabrication by inspection or waiver of inspection shall not relieve the Contractor of the responsibility to conform to the requirements for material, dimensional, accuracy, workmanship, specifications, or code requirements.

8-3250 Rev. 9-16-69 mh

200.16.1.7

CLEANING OF CARBON STEEL PIPE AND FITTINGS

200.16.1.7.1

The interior of all carbon steel pipe and fittings 3" and larger shall be blast cleaned with Black Beauty Blast Grit, Grade BB-4016, as manufactured by H. B. Reed and Company, Hammond, Indiana, or equal. Blasting shall be done to remove all mill scale, rust, varnish, paint, hydrocarbons and other foreign matter. The pipe shall be blown out after it is blast cleaned.

200.16.1.7.2

Immediately after the completion of the blast-cleaning operation, the pipe and fittings shall be immersed in an unagitated rinsing solution of Oakite #77 at a concentration of 2 ounces of Oakite #77 per gallon of water. The solution shall be maintained at a temperature of 200 degrees Fahrenheit. The solution shall be allowed to dry down on the work to provide an alkaline activated coating to the surface of the work to act as a temporary rust inhibitor.

200.16.1.7.3

The interior of all carbon steel pipe and pipe fittings, 2-1/2" or smaller, shall be cleaned in accordance with directions given in paragraphs following.

200.16.1.7.4

Immerse the work in a solution of Oakite #77 at a concentration of 8 to 10 ounces per gallon of water, maintained at a temperature of 180 to 200 degrees Fahrenheit for a period of time ranging from 30 minutes to one hour. Since the immersion time is variable due to varying degrees

2/3/67 dr



of contamination build-up on the work, the actual time required must be determined by periodic inspection. To assure the removal of all possible soils, especially a type of varnish used by pipe manufacturers as a rust retarder, a concentration of 1-1/2% by volume of "Oakite Stripper Additive" shall be added to the solution.

The purpose of this initial procedure is to clean, degrease, remove varnish and initiate action on rust and scale.

200.16.1.7.5 Remove work from cleaning solution and rinse in clear water at ambient temperature. This rinse shall be moderately agitated, by using compressed air or other mechanical means, to assure the removal of any loose soil clinging to the surfaces

of the work.

Following the rinse, the work shall immediately be immersed in a solution of Oakite #31 and water at a concentration of 5% by volume. This solution shall be maintained at a temperature of 160 to 180 degrees Fahrenheit. The immersed time required shall be determined by periodic inspection. Usual time required is 30 minutes.

This procedure is to assure the complete removal of all rust and scale.

Remove work from cleaning solution and rinse in clear water at ambient temperature. This rinse shall be heavily agitated by compressed air or other mechanical means to assure the removal of all scale and rust.

Following the second rinse the work shall immediately be immersed in an unagitated rinsing solution of Oakite #77 at a concentration of 2 ounces of Oakite #77 per gallon of water. This rinse shall be maintained a t a temperature of 200 degrees Fahrenheit. This solution shall be allowed to dry down on the work.

The purpose of the third or "drying down" rinse is to provide an alkaline-activated surface to the surface of the work to act as a temporary rust inhibitor.

200.16.1.7.6

200.16.1.7.7

200.16.1.7.8

200.16.1.8 CLEANING ALUMINUM PIPE, FITTINGS, PARTS AND FABRICATIONS

200.16.1.8.1

Prepare a solution of Oakite Aluminum Cleaner #164 at 6 to 8 ounces per gallon of water. Heat solution to a temperature of 180 degrees to 200 degrees Fahrenheit. Allow parts to soak in solution for a period of time required for complete removal of soils and contaminants. Maintain mild agitation of solution by means of compressed air introduced into solution.

200.16.1.8.2

Upon attaining required cleanliness of parts or fabrications, remove from cleaning solution and immediately immerse in clear water rinse at ambient temperature using violent air agitation of rinse water. When rinsing tubing, piping and similarly fabricated parts, an internal pressure rinse is recommended, i.e., high velocity hose stream.

200.16.1.8.3

If it is specified to remove oxides and brighten surfaces, immerse work in a solution of Oakite #34, 10 ounces per gallon at ambient temperatures (but not less than 60 degrees Fahrenheit) for a period of five minutes.

200.16.1.8.4

Following the deoxidizing and brightening process, the work shall be thoroughly rinsed in a clear water rinse at ambient temperature, using violent air agitation of rinse water.

200.16.1.9

CLEANING STAINLESS STEEL AND COPPER PIPE, FITTINGS, PARTS AND FABRICATIONS

200.16.1.9.1

Prepare a solution of Oakite #77 at a concentration of 6 to 8 ounces per gallon of water, maintained at a temperature of 180 degrees to 200 degrees Fahrenheit. Allow work to soak in the solution for a period of time required for complete removal of soils and contaminants.

200.16.1.9.2

Upon attaining required cleanliness of parts or fabrications, remove from cleaning solution and immediately immerse in a clear water rinse at ambient temperature using violent air agitation of rinse water.

200.16.1.9.3

If specified to remove stains or similar discoloration, immerse the work in a 25 percent by volume solution of Oakite #31 maintained at a temperature of 160 degrees to 180 degrees Fahrenheit for a period of time required for complete removal of all stains and discolorations.

200.16.1.9.4

Following the removal of stains and/or discolorations, the work shall be thoroughly rinsed in a clear water rinse at ambient temperature, using violent air agitation of rinse water.

200.16.1.10

DESCRIPTION OF CLEANING MEDIUMS

200.16.1.10.1

Oakite Stripper Additive - Neutral.

Application: Additive to any regular ALKALINE Oakite solution. Applicable to metals which were initially determined suitable for the Oakite solution to which it is added.

Considerably reduces cleaning time and Purpose: improves the cleaning ability of an Oakite solution. Used to accomplish removal of acrylic and epoxy lacquers.

2 percent to 10 percent Mixing Proportions: Oakite Stripper Additive to any alkaline Oakite solution,

by volume.

Operating Temperature: Do not heat in excess of 180 degrees Fahrenheit.

Precautions: NEVER ADD Stripper Additive to AN ACID OAKITE. An active reaction will occur. Do not allow contact

with skin or eyes.

200.16.1.10.2

200.16.1.10.3

Oakite #31 - Contains Acid.

Application: All metals, except aluminum.

Purpose: Removes oxides, rust, oils, and soils.

5 percent Oakite #1 to Mixing Proportions:

water by volume.

160 degrees Fahrenheit Operating Temperatures:

to 180 degrees Fahrenheit.

Precautions: Do not allow to contact skin or eyes.

Oakite #34 - Acid Power-Type Material.

Application: For treating aluminum, brass, bronze,

and copper.

To remove oxides and brighten metal Purpose: surfaces by immersion or circulation.

6 ounces to the gallon by Mixing Proportions: spray or circulation, 10 ounces to the gallon by tank

immersion.

Operating Temperature: Room temperature.

Stainless steel, Alloy 347, 316 ECL Equipment:

Precautions: Contains chromates. Do not allow

to contact skin or eyes.

Oakite #77 - Strong Alkaline. 200.16.1.10.4

Application: All metals, except aluminum.

Remove heavy deposits of soils and oils. Remove light deposits of rust and scale. Purpose:

Mixing Proportions: 8 to 16 ounces of Oakite #77

to one gallon of water.

160 degrees Fahrenheit to Operating Temperature:

180 degrees Fahrenheit.

Do not use at temperatures below Precautions:

140 degrees Fahrenheit, or when scum forms on solution. Do not allow

contact with skin or eyes.

Oakite #161 - Mild alkaline powder material.

Inhibited against attack to aluminum.

Contains depressants to prevent

excessive foaming.

Application: Cleaning aluminum by pressure spray

or circulation method.

To remove all types of soils other than Purpose:

stains and oxides.

Mixing Proportions: 3 to 4 ounces per gallon.

180 degrees to 200 degrees Operating Temperature:

Fahrenheit.

Equipment: Material safe on all metals. Ordinary

steel solution holding tanks for spray

equipment are suitable.

2/3/67 dr

200.16.1.10.5

or 304 ECL.

200.16.1.10.6

Oakite Aluminum Cleaner #164 - Mild alkaline powder material.
Inhibited against attack to aluminum.
Contains depressants to minimize foaming when agitated.

Application: Cleaning aluminum.

Purpose: To remove all types of soils other than

stains and oxides.

Mixing Proportions: 6 to 8 ounces to the gallon.

Operating Temperature: 180 degrees to 200 degrees

Fahrenheit.

Equipment: Safe on all metals. Ordinary steel

tanks are suitable.

The Contractor shall provide holding tanks or troughs of sufficient size for the specified Oakite solutions and rinses. This equipment can be fabricated in the field by cutting large diameter pipe lengthwise across the diameter and closing each end with steel plates welded to the pipe.

200.16.1.12 Expansion joints shall be decontaminated by the Contractor in the appropriate solutions depending on the joint material construction.

During the process of cleaning the pipe and fittings, the Contractor shall perform periodic titration of the cleaning solutions to assure maintenance of the specified concentrations. Upon request, titration equipment and instructions in the use thereof will be furnished free of charge to the Contractor by the Oakite Company.

200.16.1.14 Heating of the cleaning solutions and rinses as specified may be accomplished by closed steam coils, live steam, electric or gas immersion heaters or any other method sufficient to maintain the required temperatures.

200.16.1.15 Fabricated pipe spools which have been cleaned shall be capped or plugged until time of final inspection. No rags shall be used to plug pipe at any time.

200.16.1.16

In the event that the piping becomes contaminated while in the possession of the Contractor, the Contractor shall repeat the cleaning at his own expense.

200.16.2 INSPECTION OF DECONTAMINATED COMPONENTS

All components requiring decontamination will be subjected to inspection and will be considered acceptable when they pass the following:

- 200.16.2.1 Visual inspection under bright, white light. Any square foot may contain no loose particles which exceed 150 micron size and only isolated particles larger than 75 microns.
- 200.16.2.2 Ultra-violet (black light) inspection shall indicate that the cleaned surfaces are free of any hydrocarbon fluorescence. Lint or dust that may be visible under the black light shall be removed with dry, oil-free, filtered air or nitrogen.
- 200.16.2.3 Wiping with a clean, white filtered paper shall indicate no evidence of vegetable or animal oils which are not detectable by ultra-violet inspection.

200.16.3 PICKLING OF CARBON STEEL PIPE AND FITTINGS

Carbon steel pipe and fittings shall be pickled and passivated as follows:

- 200.16.3.1 Pickling: Immerse in 50% by volume muriatic inhibitive acid for 15 minutes. Flush in clean water until test with pH paper shows water to be neutral.
- 200.16.3.2 Passivation: Flush with 2% caustic soda solution.

SAFETY ASPECTS OF RECONSTRUCTED ICI TONNAGE OXYGEN PLANT

W. D. Matthews and G. G. Owen Imperial Chemical Industries, Ltd. Billingham, England

On 21st April, 1959, a serious explosion occurred in the tonnage oxygen plant at the works of Imperial Chemical Industries Limited at Billingham-on-Tees, England, during the commissioning procedures. The explosion caused three deaths, and extensive damage both to the plant and to nearby facilities, Figure 1. A comprehensive and detailed investigation was undertaken jointly by Air Products Ltd. and ICI, and expert assistance was also provided from independent sources. While the investigation concluded that the constituents of the explosive material were hydrocarbon oil from the lubricating system of the turbo expanders and liquid oxygen from leaking pipe joints in the cold box, a critical reappraisal (in the light of the growing knowledge of the hazards associated with air separation plants) of all aspects of process and engineering design, fabrication and erection, which could be regarded in any way as being potentially hazardous, was undertaken by ICI and APL prior to and during the reconstruction of the plant. At the same time, Air Products Ltd. introduced certain improvements relating to the cycle; this paper, however, is confined to consideration only of those changes which were relevant to safety.

There are several general principles to which all the changes conform. It may be convenient to enunciate these in advance of the discussion of the details:

- 1. Delineation of the area in which an abnormal oxygen concentration could occur.
- 2. Exclusion of combustibles from the "oxygen area" at all times (construction and operation).
- 3. Minimising the possibility of oxygen leakage from the plant.
- 4. Provision of safe means of disposal of high oxygen concentrations (liquid or gas).
- 5. Control of concentration of contaminants within air separation system.

Elimination of turbo expanders

The original plant obtained most of its refrigeration by means of high pressure air let down across an expansion valve, the balance being made up with expansion of 80 lbs./sq. in. gauge nitrogen in a turbo expander. These turbo expanders, which were arranged to drive induction generators through speed reducing gears, projected into the main cold box shell and were oil lubricated, Figure 2. Following the explosion in the original plant, a careful investigation led to the conclusion that the explosion took place external to the plant equip-

ment and that the major combustible component in the explosion was spilt lubricating oil.

The general decision was made that the reconstructed plant should be fenced, with rigid control of hydrocarbons inside the compound. The choice was offered to us by Air Products Ltd. of balance refrigeration coming from either a Freon evaporator system or from turbo expanders, both housed external to the main cold box shell. Either system was acceptable both on technical and safety grounds, but it was considered that the Freon evaporator system offered less chance of oil contamination either inside or outside process equipment. With this in mind, a Freon evaporator system was chosen. The system was placed outside the compound and connected to the cold box by insulated air piping.

The original plant produced both high pressure and medium pressure oxygen gas products by vaporizing pumped liquid oxygen. The low pressure oxygen stream was produced by taking a proportion of high pressure oxygen liquid, letting it down in pressure and vaporizing it in a shell and tube exchanger. It is well known that this type of vaporizer-exchanger has its contamination problems and it was decided to eliminate it in the rebuilt plant. The medium pressure oxygen gas product is now produced by taking a supply of gas from the L.P. column base and compressing this externally.

Long term analysis of hydrocarbon contamination

The Air Separation Plant site is located in the center of a very large chemical complex. In view of this it was considered important to know the type and level of hydrocarbon contaminants that could occur in the atmosphere of the plant site, and a long term series of tests was undertaken (lasting two to three years) to obtain qualitative and quantitative values for the hydrocarbon contaminants in the atmosphere under all conditions of wind direction and velocity throughout the year. Samples were taken at 200 ft. and 40 ft. levels, the respective heights of our alternative air intake stacks.

Analyses were carried out by drawing a continuous sample of air through soda asbestos towers (to remove carbon dioxide and water) before passing through charcoal packed adsorbers cooled to -112°F. At the end of each 2-hour sampling period the charcoal tubes were taken to the laboratory and degassed. A concentrated sample of impurities was then analyzed using a mass spectrometer. In general, contamination was found to be lower at the high intake level. Maximum fig-



PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 1 OF 7

DATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

I. PURPOSE

To establish a standard procedure to assure the adequacy of personal protective equipment by setting standards for its testing and maintenance.

II. RESPONSIBILITY

The Plant Manager, or the man he designates, shall be responsible for maintenance and routine checks on personal protective equipment.

III. PROCEDURE

A. Scope

Equipment to include all protective devices such as:

Chemical Gloves
Ear Protection
Safety Hats or Caps
Gauntlets for liquid handling
Safety Glasses
Goggles (All types)
Ear Protection
Safety Hats or Caps
Face Shields
Respiratory Equipment
Safety Harnesses and lanyards

B. General

- 1. All personnel shall be instructed to:

 Check the condition of all protective equipment before using;

 Report any unsatisfactory equipment, or suggest additional equipment where required, to the supervisor;

 Report items missing from proper stations (such as shields and chemical gloves from caustic areas or face shields at grinders); and

 Replace equipment after use, making sure that items for use in a specific area are not taken from that area.
- 2. The person responsible for maintenance and inspection of safety equipment shall attend to the following:
 - a. Plant facilities shall be inspected for unsatisfactory materials and missing equipment. The need for new equipment and materials shall also be noted.



PAGE 2 OF 7

DATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

- b. A current inventory of personal protective equipment (all equipment listed in A, above and any special equipment required at a particular facility) shall be kept, as required for prudent facility operation.
- c. Where possible, defective equipment shall be repaired or replaced at the time of inspection, and spare parts reordered as necessary.
- d. Breathing apparatus, canisters, and cylinders, shall be tagged, indicating last inspection date, and signed by the inspector.
- e. Sufficient quantities of safety glasses and safety caps shall be kept clean and readily available for transient and visiting persons. These shall be cleaned with a germicide before reuse by others.
- f. Records shall be kept of nonexpendable items which are issued to employees. Employees shall sign for this equipment and return it if terminated.
- C. Monthly Inspection and Maintenance (exceptions noted). Use good judgment when checking the equipment listed below. Increase the frequency of checking if heavy usage of specific items demands it.

1. Gloves, gauntlets

a. Check general condition. Gauntlets and asbestos gloves shall receive particular attention at seams. Chemical gloves shall be stretched to check for holes or deterioration and replaced as necessary. Polyvinyl alcohol gloves are required for methylene chloride service and shall be so identified.

2. Electrical Gloves

- a. Check for punctures or abrasions each time they are worn.
 Test roll, starting with the cuff. Force air into fingers and palms. If there is leakage, DO NOT USE.
- b. Electrical testing service shall be provided. Test intervals shall be determined by the frequency of use and by voltage they are subject to. Frequent use laboratory tested every 6 months. Infrequent use test every year.

Air Products and Chamicals

PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 3 OF 7

DATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

- c. Check leather protectors which are worn over rubber gloves to protect from mechanical damage, oil, and grease.
- d. Gloves shall be kept in special pouches, free from moisture and dirt.
- 3. Eye and Face Protection.

This includes chemical goggles, impact goggles, filter goggles (welding), face shields, and individual employees' safety glasses.

- a. Check for missing screws or other hardware and replace if necessary.
- b. Check for scratched, fogged, or pitted lenses and replace if necessary.
- c. Check for broken hinges or frames and replace if necessary.
- d. Replace complete units which are irreparable.

4. Safety Caps (hats)

- a. Materials of construction shall be water-, fire-, and acidresistant and nonconductors of electricity. There shall be no metal parts in the shell or suspension.
- b. Shell, suspension, and sweatband shall be inspected for good general condition. Look for:

Cracks, cuts, signs of impact and rough treatment of shell; Alterations (cuts, holes in shell); and Worn or torn suspensions.

- c. Damaged shells or suspensions must be replaced. They must not be painted, drilled, or trimmed. The only permitted markings are the company trademark decal and/or the employee's name decal.
- 5. Safety Belts, Harness, and Linyards
 - a. Inspect entire harness, lanyard, and lifeline for wear (fraying, cuts, abrasion) and deterioration, which might cause the harness to fail under heavy jar or shock.

Air Products and Chemicals

PROCESS EQUIPMENT DIVISION PLANT OPERATIONS MANUAL

PAGE 4 OF 7

DATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

- b. Check buckle and adjusting mechanism for absence of slippage.
- c. Check rivets and grommets for security.
- d. Store belts in a clean, dry place.
- e. Lifelines shall be stored in a similar manner, neatly coiled and free of knots.
- f. Belts and ropes in service should not be weight tested.
- g. Damaged or deteriorated belts and ropes shall be discarded and replaced.

6. Breathing Apparatus

a. General

- (1) All personnel shall be properly trained in the use of respiratory equipment.
- (2) Face masks of all types, if used by more than one person, shall be cleaned and disinfected after use, to prepare them for use by others. The mask and associated elastic headbands shall be washed in a solution of germicidal detergent and water. Parts are then rinsed in clean water and dried.
- (3) Equipment shall be stored in a cool, dry, clean, dust-free cabinet.
- (4) Each face mask must be kept in a separate plastic bag.
- b. Filter and Cartridge Respirators
 - (1) The filter element shall be checked and dirty elements shall be replaced.
 - (2) Head band adjustment devices shall be checked for elasticity.
 - (3) Mask shall be checked for holes, cracks, or deterioration.

Air Products and Chemicals

PLANT OPERATIONS MANUAL

PAGE 5 OF 7

DATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

(4) Exhalation valves shall be checked for condition and operation and replaced if unsatisfactory.

c. Air Line Respirators

- (1) Air Line respirators shall be checked as in C,6,b, above for filter and cartridge respirators.
- (2) Pressure regulator, filter, hose, and facepiece shall be checked for operability and condition.
- (3) Air supply shall be checked to ensure continued proper functioning. The following shall be kept in good repair:

Air compressor; Air cylinder manifold system; Pressure relief valves; Air line filters; Air line instrumentation; and Permanent piping and outlet fitting.

(4) Flow control valve shall be checked, and cleaned and repaired if necessary.

d. Gas Masks

- (1) Canisters shall be stored, handled, and replaced as directed by their manufacturer. Out-of-date canisters shall be punctured and disposed of.
- (2) Cracked, pitted, fogged, or distorted lenses shall be replaced by qualified personnel or returned to the manufacturer. Makeshift repairs can jeopardize the life of the wearer.
- (3) Head harness and facepiece shall be tested for flexibility. Condition of straps and buckles shall also be checked.
- (4) Check exhalation valve for proper installation, cleanliness, and operation.
- (5) Breathing tube shall be checked for flexibility, freedom from custs or cracks and security to canister neck or outlet of the timer.

Air Products and Chemicals

PLANT OPERATIONS MANUAL

PAGE_6_ OF _7_
DATE __04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

- (6) If a timer is used, testing shall be done to see that the gaskets are in place and that the timer is reset when a new canister is used.
- (7) Whennot in use, canisters shall be protected from moisture. When stored, the seal on the bottom opening of the canister shall be unbroken.
- (8) Since the mask is for emergency use only, canister shall be replaced after use.

Note: Gas masks shall be used only when a positive check of the atmosphere has been made to be certain that the atmosphere contains at least 18 per cent of oxygen. Percentages lower than 18 per cent oxygen require the use of self-contained air or air line respirators.

- e. Self-Contained Breathing Equipment (Scott Airpacks)
 - (1) The storage case shall be inspected for general condition.
 - (2) Equipment shall be checked to see if it is complete and in good condition.
 - (3) Cylinder pressure shall be checked and cylinder shall be refilled if pressure is below the manufacturer's pressure recommendations. Oxygen shall not be used.
 - (4) Every three months the equipment shall be donned and the mask, hose, regulator, and exhalation valve shall be checked.
 - (5) Every three months the quick connection shall be disconnected. the cylinder valve shall be closed and the hold pressure of the equipment shall be checked with 1800 psi on regulator gauge.
 - (6) The cylinder shall be hydrostatically tested every $\underline{5}$ years.
- f. Hose Mask
 - (1) Blower shall be checked for proper operation.



PAGE 7 OF 7

PATE 04/21/67

PERSONAL PROTECTION EQUIPMENT MAINTENANCE

- (2) Check hose shall be checked for cleanliness and for general condition.
- (3) Hose and blower shall be capped when not in use.
- 7. Ear Protection.

Ear muffs and ear valves shall be checked for general condition.

- 8. Stretchers
 - a. Stretchers shall be checked to see that they are at their locations and stored properly.
 - b. Number and condition of lanyards shall be checked.
- 9. First Aid Supplies

Inventory of first aid supplies shall be checked and replacements made as necessary.

10. Signs, Barricades, and Safety Rope

Signs, barricades, and safety rope shall be inventoried and its general condition noted. Repairs or reordering shall be done as necessary.

IE/PR

10th February 1971

SAFETY DEPARTMENT INFORMATION SHEET NO. 38

FIRE HAZARD WHEN VAPOUR CLEANING WITH TRICHLOROETHYLENE (T.C.E.)

It has been suggested that T.C.E. can sometimes present a fire hazard. However, it should be noted that T.C.E., under normal circumstances, is non-flammable and will not support combustion.

Standard T.C.E. Vapour Cleaning Plants

The following precautions will eliminate fire hazards from the use of T.C.E. vapour cleaning plants.

- 1. A device (e.g. a top thermostat) is needed to interrupt the heat supply to the sump if the vapour rises above the normal working level. Otherwise a slight risk exists of an inflammable T.C.E. air mixture forming. However, any flame would not be self sustaining.
- 2. If an electrical immersion heater is used to vaporise the T.C.E. liquid in the sump, a sump thermostat is required to prevent local overheating. Steam or hot water heating is safe.
- 3. The T.C.E. level must be checked daily and maintained in the sump. Complete loss of T.C.E. can expose flammable oil/grease mixtures to the atmosphere.
- 4. Fresh T.C.E. should be added when the plant is cold. If this is done with the plant hot, the T.C.E. on contacting hot oil/grease etc. in the sump is rapidly vaporised, displacing from the plant flammable oil vapour before it can be diluted with T.C.E. vapour.
- 5. Use only specially stabilized grades of T.C.E. with aluminum or its alloys otherwise a slight fire risk exists.
- 6. T.C.E. must always be segregated from strongly alkaline materials e.g. caustic soda, caustic potash, soda lime, silver oxide. Otherwise a danger of fire/explosion will exist.
- 7. Do not permit naked flames, welding, brazing, soldering or smoking in the vicinity of a T.C.E. vapour plant when in use. Otherwise poisonous corrosive gases may form.
- 8. Do not store oxygen cylinders near a T.C.E. vapour plant as leaking oxygen would increase the oxygen content of the atmosphere locally and increase the fire/explosion hazard.

Sheet 2

Use of T.C.E. for Cleaning in Air Separation Plants

- 1. Additional hazards arise from the presence of oxygen in air separation plants when T.C.E. is used for cleaning usually by brushing or swabbing. It has been established that flammable T.C.E. 0₂ N mixtures can exist with oxygen concentrations between 25 and 90%. A temperature of 419°C (787°F) can cause ignition of such a mixture.
- 2. However, the vapour pressure of T.C.E. below 25.5°C (78°F) is too low to produce the necessary concentration of T.C.E. vapour to create flammable mixtures even with high oxygen concentrations.
- 3. Therefore, cleaning operations using T.C.E. should not be carried out where there is a definite possibility of local increases of oxygen concentration occurring and where cleaning has to be done in areas where high oxygen concentrations might exist it is essential that cold T.C.E. always be used and no heating be employed to assist cleaning or assist in the removal of the T.C.E. after cleaning.

K. J. Coulson (Head of Q.C.D.)

I. Everson
(Chief Safety Engineer)

References

Imperial Chemical Industries Ltd., Mond Division, Technical Service Note TS/B/2246/2.

U.S. Department of the Interior - Bureau of Mines, Report of Investigation RI 3666 Nov. 1942 by C. W. Jones and G. S. Scott.

Air Products and Chemicals discontinued the use of Carbon Tetrachloride (Carbon Tet) as a cleaning solvent in 1953 upon the issue of Cylinder Gas Division Procedure 10.2-1 because of the potential toxicity problems associated with its handling and use. The use of Carbon Tet has since been prohibited in all corporate activities except as authorized in certain laboratory applications.

Carbon Tet is an inexpensive, nonflammable solvent that was used extensively as a dry cleaning, metal degreasing and fire extinguishing agent. This so-called safety solvent caused 20 deaths during a six-year period (1948-1954) in California. During the same period, 200 lost time injuries were caused by the use of Carbon Tet.

Carbon Tet may injure a person by breathing the vapor, by swallowing the liquid, and by contact with the skin or eyes. Once Carbon Tet enters the body it is absorbed by the fatty tissues of the body. These tissues are primarily the liver and the fatty deposits under the skin. It also affects the brain cells. In addition, Carbon Tet interferes with the kidney function and if the exposure is high enough, the kidney stops functioning. Alcohol alters the liver's ability to detoxify Carbon Tet so that a concentration which would not be dangerous without exposure to alcohol now becomes fatal.

Ten parts per million Carbon Tet are considered safe for continuous breathing up to periods of eight hours as established by the American Conference of Governmental Industrial Hygienists in 1962. The previous recommended limit was 50 ppm and later 25 ppm.

Carbon Tet vaporizes rapidly and mixes thoroughly with air. About $\frac{1}{4}$ teaspoon of Carbon Tet vaporizing in a room 10 ft. x 10 ft. x 10 ft. will result in approximately 10 ppm, the limit of exposure for people.

References:

National Safety News, January 1956. "What Do You Know About Carbon Tet?" by R. M. Farrier, M.D. Bulletin 125, State of California, Division of Industrial Safety

SAFETY DEPARTMENT WWSchmoyer/bp

PUT IT IN WRITING

			DateDecember 11, 1961
TO	B. F. Wobker	SUBJECT	Detonation Tests of Oil from Aliquippa
			Pump Suction Filter Defrost and of
FROM	E. Kehat		Methylene Chloride
cc:	Ball, I		Master, H. H.
	Bonning, K.		McKinley, C.
	Ent, W. E.		Rector, W.
	Geist, J. M.		Wyan, H.

The recently developed APCI ignition test was used for these tests. In this test identical equipment and technique are used for increased reproducibility. Pressure bombs have a volume of 11 cc. and surface area of 0.04 sq. ft. The tested material is evenly applied to the surface. The bomb is sealed and connected to a manifold where it is evacuated, purged, and pressurized with oxygen and ignition is applied. The igniter is a 0.15" length of .003" type 304 stainless steel wire that is evaporated by the application of current at 6.4 volts.

Six pressure bombs are used for each test. About 0.2 - 0.25 of oil is required and the oxygen pressure is 2000 psig.

Oil Tests

Two bombs showed no reaction. In two bombs the pressure rose to over 3000 psig in 3 - 5 seconds. At this pressure level the sealant or the electric wires blow out, and the pressure is released. One bomb detonated; the sealant blew off upon ignition initiation. In one test the ignition wire broke. The oil is definitely detonatable in oxygen. The three bombs that ignited were very hot and very little oil was found in the tarry and carbonaceous residue.

Methylene Chloride

One cc. of fluid was used in each bomb to compensate for handling losses due to the high volatility of the fluid.

One bomb was run with the ignition wire up. No ignition occurred. The other five were run with the bombs upside down. Two samples detonated. In three, the pressure rise to the sealant blow out pressure occurred over a period of a few seconds. All five bombs were hot and contained carbonaceous residue.

Oil in Methylene Chloride

Since the solvent was as reactive with oxygen as the oil, the plan to run a solution of oil in solvent was shelved.

ORIGINAL	SIGNED BY
E.	Kehat

EK:Faj (Retyped 9/20/72 sjw)

NOTES ON
LIQUID OXYGEN CONTAMINANTS
MISSILE PROGRAM

NOTES ON

LIQUID OXYGEN CONTAMINANTS MISSILE PROGRAM

OUTLINE

OBJECTIVE AND SUMMARY

SCOPE OF INVESTIGATION

Sources of Liquid Oxygen Analysis for Trace Impurities Methods of Distribution Protection Against Contamination During Distribution

THEORETICAL CONSIDERATIONS

Safety Aspects Formation of Solids

RECOMMENDATIONS

Monitoring Reduction of Vaporization

NOTES ON

LIQUID OXYGEN CONTAMINANTS

MISSILE PROGRAM

OBJECTIVE AND SUMMARY

Since the failure of some rocket engines employing liquid oxygen in theory might be attributed to insoluble contaminants precipitating in valves or small orifices in the engine, a short program was undertaken to determine whether or not such contaminants are present in liquid oxygen being supplied to missile launching sites or if contaminants could enter or accumulate in the liquid in the process of storage and distribution prior to firing.

In light of observations, primarily at Cape Canaveral, two recommendations are made:

- 1. Analytical monitoring of the liquid oxygen for insoluble impurities should be undertaken after its final transfer.
- 2. The concentration of impurities through oxygen vapor losses in storage and distribution should be minimized by careful evaluation of transfer procedures and of design of storage and transfer equipment.

SCOPE OF INVESTIGATION

Sources of oxygen. The liquid oxygen used in the missile program is obtained from air separation equipment. The variety and concentration of contaminants in the liquid will, therefore, depend on the source of air and the type of liquefaction cycle employed. Air separation plants located at relatively remote missile launching sites should produce "cleaner" oxygen than those operating in industrial atmospheres. Plants specifically designed for liquid production will normally produce "cleaner" oxygen than those requiring a large quantity of oxygen gas withdrawal to provide refrigeration. Analyses at Patrick Air Force Base indicated that liquid oxygen supplied in tank cars contained a higher level and greater variety of contaminants than the liquid oxygen from plants located on Cape Canaveral. The tank car oxygen analyses indicated the presence of methane, total hydrocarbons, carbon dioxide, carbon monoxide, ethylene, and acetylene at levels several times the concentrations determined in oxygen from the Cape Canaveral plant, where, in fact, carbon monoxide, ethylene, and acetylene were not detectable. All contaminants, however, even in the tank car oxygen, were below their solubility limits in liquid oxygen at its normal atmospheric boiling point. The Cape Canaveral analyses were performed in the Patrick Air Force Base Chemical Laboratory by Mr. Normile and Mr. Cameron using a Perkin-Elmer dispersive type infra-red spectrometer. Correlation of the total hydrocarbon and carbon dioxide analyses was made with an Air Products Total Hydrocarbon Analyzer employing a non-dispersive type infra-red analyzer sensitized for carbon dioxide preceded by a catalytic oxidation unit which converts all hydrocarbons and carbon monoxide to carbon dioxide.

Using the Total Hydrocarbon Analyzer at Air Products test site near Wilkes-Barre, Pa., and at Fort Belvoir, Va., it was determined that the total hydrocarbon and carbon dioxide concentrations in liquid oxygen produced by 5-Ton per day and 20 Ton per day mobile generators were also below their solubility levels. Separate specific tests for acetylene using Ilosvay solution at the Wilkes-Barre site were negative, indicating an acetylene content of less than .05 ppm, far below a hazardous level.

Summarization of analyses of liquid oxygen as produced, then, indicates that normal contaminant levels are low enough that neither a safety hazard nor functional problems should occur unless further concentration takes place during distribution and storage. To the extent of the sampling to date, the liquid oxygen produced on the site provides a greater margin of safety against excessive contaminant concentration than liquid transported in tank cars.

Methods of Distribution: Although distribution systems differ from location to location, a generalized system contains the following elements:

- 1. Liquid Source; on-site plant or rail-head.
- 2. Mobile Transport.
- 3. Ready Storage Tank.
- 4. Liquid Oxygen Receiver in Missile.

In some places where on-site plants with suitable reserve storage are employed, the ready storage tanks and associated pumping and distribution systems have been eliminated.

Between each of these elements a liquid transfer is, of course, required. At rail heads, warm-up coils are frequently used to develop pressure for transferring liquid from tank cars to motor transport trailers through flexible metal hoses. Most on-site plant facilities include storage capacity equivalent to several days production. These storage tanks, permanently connected to the plants, are fed principally by gravity. In some cases, transfer from the tanks to mobile trailers is effected by gravity. At other locations, liquid oxygen pumps are employed. The mobile trailers are also equipped with liquid oxygen pumps to deliver the liquid at relatively high rates to the missile directly or to ready storage. Again, flexible hoses are used. Where ready storage equipment is employed, liquid is pumped to the missile through non-insulated lines at high transfer rates.

Protection Against Contamination During Distribution. As indicated in the preceding discussion of distribution systems, several liquid transfers are required where connections are frequently made and broken. Protection against the entry of dirt, sand, rust or other particles must be provided, as well as careful sealing against atmospheric contaminants, mainly moisture, which could readily condense in lines during cool-down. In practical application at sites visited, fittings are inspected before connections are made and, following use, all lines are carefully sealed.

Some of the transfer lines contain filters to screen particles which may have entered the liquid in spite of handling precautions.

According to the Military Specification, MTL-P-25508 (USAF) 29 March 1956, the only purity requirement is that liquid oxygen for missile use be at least 99.5% oxygen. At permanent on-site generating plants, this purity is verified

by continuous analyzers calibrated against the specified cuprous ammonium chloride chemical test. Frequent chemical tests by this method are applied on mobile generators. It is assumed that liquid transported to missile launching sites from commercial plants is also tested according to the military specification.

No additional specific analytical program for detection of contaminants is presently followed as a uniform practice.

THEORETICAL CONSIDERATIONS

Safety Aspects. Although primary interest has been focused on detection of contaminants which could functionally impair engine performance, the appearance of acetylene and other hydrocarbons in the tank car analyses brings the aspect of safe handling into the picture. The possibility of a fire or explosion with liquid oxygen does not exist until a combustible is present in excess of its lower explosive limit. To reach the lower explosive limit of materials soluble in liquid oxygen requires gross contamination not likely unless a fuel were accidently mixed with the liquid oxygen. However, in the case of very insoluble materials (acetylene is the most noteworthy example) the solubility limit becomes the lower explosive limit, for when the solubility limit is exceeded, local concentrations within the explosive range may be formed. Since these insoluble materials have extremely low vapor pressures at liquid oxygen temperature, vaporization of the oxygen will always be accompanied by an increase in their concentration. Where the solubility of the contaminant is low (acetylene's solubility is less than 5 parts per million), the approach to a hazardous condition can be visualized. Although the approach to a hazard is speculative, the importance of (1) a low contamination level from the source, (2) reduction of vaporization in handling, and (3) control monitoring for impurities becomes apparent.

Formation of Solids. Primary attention of this brief study has been focused on the possibility of forming solids in liquid oxygen during the process of distribution from the liquid source to the receiver of the missile. Carbon dioxide is considered to be most important in this respect, although ice from water vapor and solid hydrocarbons have not been discounted. (Entry of inerts

such as sand, metallic particles, valve and pump packing materials, and threading compounds, while of serious practical importance, is not herein discussed.) The vapor pressure of solid carbon dioxide at -300°F is .0000001 psia. Therefore, as oxygen boils, the carbon dioxide will remain in the liquid and tends to concentrate in proportion to the oxygen vapor loss. Since the solubility of carbon dioxide in liquid oxygen at atmospheric pressure is only 4 parts per million, it is evident that excessive oxygen vaporization in storage, or in transfer could readily increase the carbon dioxide content of liquid oxygen to a level above its solubility. The tests at Cape Canaveral showed that the carbon dioxide content of liquid taken directly from the on-site air separation plant was on the order of one to two parts per million, whereas analysis of liquid of tank car origin sampled from a ready storage tank indicated a carbon dioxide level well above its solubility. The exact level cannot be placed since the validity of sampling can be questioned whenever the solubility is exceeded. Nevertheless, there is evidence that solid particles of carbon dioxide must have been in suspension in the liquid oxygen. Upon further transfer in which lines, pumps, and the liquid receiver of the missile were cooled-down, a substantial quantity of oxygen was again vaporized, and more carbon dioxide must have come out of solution. Its behavior in the internal distribution system of the missile and the effect of possible localized concentrations of solid carbon dioxide on combustion characteristics have not been investigated as a part of this study.

RECOMMENDATIONS

Monitoring. The effect of solid contaminants in liquid oxygen on the performance of missile engines can be resolved by careful monitoring of the liquid oxygen after its final transfer. Correlation of analyses with reference to the solubility of the contaminant investigated should be made against engine performance. In the event that contaminants do reach a troublesome level, diagnostic tests should be made at points in the distribution system to determine where concentration is taking place.

Monitoring instruments, easily calibrated and sufficiently rugged for test site use, would be preferable to laboratory analysis involving delay and transfer of samples which permit liquid vaporization. Carbon dioxide, relatively insoluble hydrocarbons and water are suggested as materials capable of passing through filters either in solution or as very fine particles which could then be concentrated in the missile receiver. These deserve special attention in the monitoring program. The sensitivity and range of the monitoring instruments is dictated by the solubility of contaminants in question.

From the standpoint of safety, storage facilities should be monitored for total hydrocarbons and for acetylene in particular.

Reduction of Vaporization in Distribution Systems. To a large degree, the very nature of the air separation process precludes the presence of contaminants near their level of solubility. This is especially true where the cycle is designed specifically for liquid production and where hydrocarbon adsorbers are employed. Concentration of contaminants, then, will occur primarily in the liquid oxygen distribution system after the liquid leaves the air plant.

Cognizance of the fact that vaporization losses are accompanied by a concentration of impurities must be reflected in handling practice and in design of the components of the distribution system. No criticism of handling procedures presently practiced is implied. In fact, transfers observed (at Cape Canaveral and Santa Susana) were characterized by extreme care from the standpoint of safety and cleanliness.

Franklin Himmelberger Research Department Air Products, Inc.

January 6, 1958

(Retyped 9/21/72 jes)



PUT IT IN WRITING

		Date November 17, 1961
TO	C. McKinley	SUBJECT Development of Standard Ignition
FROM	E. Kehat	Test. Interim Report - Project No. 87-0-8820/1
cc:	Ball, L. Foster, R. Geist, J. M.	

ABSTRACT

The recently developed ignition bomb test is fully described. The results of 76 tests are summarized. The results obtained to date are encouraging: the method is sensitive and reproducible. Tests of the sensitivity of the method are being continued.

INTRODUCTION

The ignition bomb method we have been using in the past few months has been modified considerably. Its present form is flexible in use, easy to clean and reuse, relatively inexpensive, capable of operation at high pressure, fairly sensitive, and reasonably reproducible.

This report is a progress report on the work done in the past few weeks in evaluating this ignition method, and on the results of some recent tests.

THE IGNITION BOMB

A full size drawing of the ignition bomb is attached. The body of the bomb is a 4-inch length of heavy wall 3/8" brass pipe. A 1/4" copper tubing side arm is brazed to the pipe for the introduction of gases. Other connections are made by pipe threads at top and bottom of the pipe, sealed with Teflon tape. The pipe is connected to a 3/8" stainless steel cap at the bottom and to standard Tylock brass fittings at the top.

The igniter is a 0.12" to 0.15" length of .003" type 304 stainless steel wire of about 0.6-0.8 ohms resistance. The wire is fused by passing through it current at 6.4 volts. (At higher voltages the wire vaporizes faster, but with less intensity, and at lower voltages a lower temperature of the wire is obtained. The optimum voltage of 6.4± 0.2 volt was established experimentally.) The ignition wire is soldered to two bare copper wires that pass through a pressurized Teflon sealant. Thus the materials inside the tube are: copper, brass, stainless steel, Teflon, and a minute amount of soft solder on the ignition wire ends. If necessary, stainless steel pipe, wires



C. McKinley 2 November 17, 1961

and fittings can be substituted for the copper and brass, and cold welding can be used instead of solder on the ignition wire, so that only stainless steel and Teflon are exposed in the system. The only non standard item used is the Teflon plug that requires about 20-30 minutes of labor to produce (in small quantities). This plug is now made in two sections so that if the bottom part is partly melted, another can be substituted cheaply. Since the pipe can be opened from both ends it is easily cleaned and reused.

The volumes of the ignition bombs, determined by filling 3 units with distilled water, are 10.9 ± 0.1 cc. The internal surface area, determined by dimensional measurements, is $.039 \pm 0.03$ sq. ft.

Eighteen such bombs are available at present.

PROCEDURE

The manifold shown in the second drawing is located in the ignition cell in Plant #1. It was originally built for the N₂F₂ tests. Similar manifolds are used for other tests. The oxidant cylinder is usually upright and the pressure gage used, usually has twice the range of the test pressure. The pressure gage is read with the aid of a mirror. The valves are operated from outside the ignition cell. The switches for the vent blower, the vacuum pump, and the igniter are also located outside the cell. An ohmmeter is connected across the ignition wire to check if the wire vaporized.

The pressure bombs are throughly cleaned by solvents and brushing, and assembled. Gases are loaded through the manifold. Solids are loaded in the form of shavings and the bomb is connected upside down in the manifold so that the shavings are close to the ignition wire. Liquids are loaded either in solution in a solvent that is then evaporated or as liquid drops that are thoroughly agitated to spread as a thin film on the inner surface of the bombs.

The ignition procedure is: The ignition bomb is connected to the manifold and the ignition wires are connected to the 6.4 volt source. The manifold is vacuum pumped and then purged three times with nitrogen and vacuum pumped again. The gas or gases are introduced at the desired pressure level and the ignition current is turned on. The Ohmmeter shows that the wire has vaporized.

The pressure gage is watched for pressure change and the outside of the bomb is checked for heat. Eventually this part can be done instrumentally, however the response of a thermocouple attached to the bomb for midly reactive systems (low pressure N₂F₂) was poor. A post mortem of the bombs to check the residue aids in determining whether ignition occurred in less sensitive systems.

If due to ignition the pressure inside increases to 2700-3600 psig, the Teflon plug is ejected, sometimes with great force. This serves as a relief device. So far, none of the bombs were distorted or bulged even when exposed momentarily to 4000 psig.

C. McKinley 3 November 17, 1961

SENSITIVITY OF THE IGNITION BOMB METHOD

Three sets of tests were planned to test the sensitivity of the ignition bomb method:
(a) surface concentration, (b) sensitivity of this method compared to data from impact testing, and (c) sensitivity of this method in LOX. Only set (a) was finished so far and is described below.

A considerable amount of data was obtained in Project 03-9-2881 on the effect of surface concentration on ignition of hexadecane in oxygen and in LOX; using spark igniton. Ignition is insignificant below 100 mg/sq. ft. At higher surface concentrations the oil film flows on the surface and creates high local concentrations.

A series of solutions of hexadecane in carbon tetrachloride: 4%, 1%, 0.25%, and 0.08% were prepared. Ignition bombs were filled with a solution and the solvent was boiled off in a boiling water bath. Inspection of such bombs showed a slightly blotched film, reasonably even. Six bombs were used at each concentration. The lowest concentration was not used. The three concentrations used correspond to surface concentrations of 3250 mg/sq. ft., 2070 mg/sq. ft., and 520 mg/sq. ft. The initial oxygen pressure in all tests was 200 psig.

Surface Concentration of 8250 mg/sq. ft.

- 1. 10 psi surge. Bomb warm. Sealant melted.
- 2. 50 psi surge. Bomb hot (60°C). Sealant melted. Black residue from oil.
- 3. 10 psi surge and slow rise of additional 40 psi. Bomb hot. Sealant melted. Some oil left.
- 4. 1-2 psi surge. Bomb warm. Sealant intact. Most oil left.
- 5. Initial surge and slower rise of 50 psi. Bomb hot. Sealant melted. Trace of oil left.
- 6. Wire shorted.

Three out of the five bombs tested showed similar results and the other two also showed signs of ignition.

Surface Concentration of 2070 mg/sq. ft.

- 1. Slight leak. Pressure surge. Bomb warm. Sealant melted. Bomb clean (no oil).
- 2. 30 psi surge and slower rise of additional 12 psi. Bomb hot. Sealant melted. Bomb clean.
- 3. Slight surge. Bomb slightly warm. Sealant intact. Oil traces in bomb.
- 4. Slow rise of 30 psi. Bomb hot. Sealant melted slightly. Bomb clean.
- 5. Surge and then slower rise of 55 psi. Bomb hot. Sealant melted. Bomb clean.
- 6. 2 psi surge. Bomb slightly warm. Sealant intact. Traces of oil in bomb.

The reproducibility of these tests was poorer than for the high concentration. However evidence of ignition was obtained in all tests.



C. McKinley 4 November 17, 1961

Surface Concentration of 520 mg/sq. ft.

1-5 No apparent reaction.

Surge and then slow rise of 40 psi. Bomb warm, Sealant melted. Some oil left.

At this concentration, reproducibility of ignition was much poorer. Therefore, the lower concentration samples were not run. The sensitivity of ignition to surface concentration is approximately the same as for the previous tests in larger pipes.

In order to obtain reproducible results concentrations of approximately 5000 mg/sq. ft. are required. This amounts to about 0.2-0.25 cc. of oil per pressure bomb.

Ignition tests in LOX, obtained by condensing oxygen, at liquid nitrogen temperature in the ignition bomb, at this concentration level will be carried out this week. Some chlorinated hydrocarbons which cover a wide range of sensitivities to impact testing will be tested next, in order to compare the sensitivity of the ignition bomb method with that of impact testing.

OTHER TESTS

NoFo Ignition Tests

These tests were reported in a note dated October 17th. Six tests of 6 bombs each were used at pressures of 13-23 psig. Despite the low pressure, in each of the four series of tests that showed signs of ignition, 3-5 bombs gave the same signs of ignition: 1-2 psi pressure rise, slight warmth of bomb, and some charring of residue.

Silicone Oils (Dow Corning RF-1-0035, 1000 C.S. and 10,000 C.S.)

These oils were tested with spark ignition at 100 psig oxygen (note from August 22, 1961) and showed no sign of ignition. These oils do not burn in air if ignited with an acetylene torch, after the torch is removed.

The 1000 C.S. oil was run again in six of the new pressure bombs. 0.2 cc. of oil and 100 psig oxygen were used with no sign of ignition.

Another set of tests was made, with 0.2 cc. of this oil, at 2000 psig oxygen. In four tests there were no signs of ignition. However, in two tests the pressure went up (to 3500 psig in one and to 2800 psig in the other) and the Teflon plugs blew out. The bombs were hot. The sealant melted and a carbon residue was found in these bombs.

A set of tests was made with 0.2 cc. of the 10,000 C.S. oil, at 2000 psig oxygen. In the first three tests the pressure rose to 3200-3700 psig and the Teflon sealant was blown out. In one case a bright flash of flame followed the sealant blow out and carbon was found in the bomb. After these powerful demonstrations, it was not considered necessary to run the other 3 prepared bombs.

1



C. McKinley 5 November 17, 1961

Indopol Polybutent Oils (Amoco L-10 and H-100, H-100 high viscous)

These oils and mixtures of these two oils were tested in June and September 1957 in glass test tubes with liquid oxygen and blasting cap initiators. Of eight tests two did not explode, two resulted in slight explosions, two resulted in medium explosions and two resulted in very sharp explosions. The results obtained with the ignition bomb method with gaseous oxygen were much more consistent.

A set of six tests was made with the less viscous oil (L-10). 0.2 cc. of oil and 2000 psig oxygen were used.

In two tests enough of the sealant melted to release the pressure of about 2700 psig. In the other four tests the pressure built up to 3300-3700 and blew out the sealant with a flash of white flame and a very loud noise. Considerable amount of sealants melted. Carbon deposits covered the inside of all bombs. In one case melted copper from a lead wire was found, indicating temperatures of above 3600°F.

A set of six tests was prepared for the more viscous oil (H-100) but only one was run. In this test the pressure went up to 4000 psig before the sealant blew out. Some discoloration of the metal surfaces was noted but no carbon deposits. It was not considered necessary to run the other samples.

CONCLUSIONS

The ignition bomb test method compares favorably with tests run in APCI by other methods, and gives a degree of reproducibility higher than many other known ignition tests. The limits of sensitivity of the method are still being investigated.

Original Signed By

E. Kehat

EK:faj

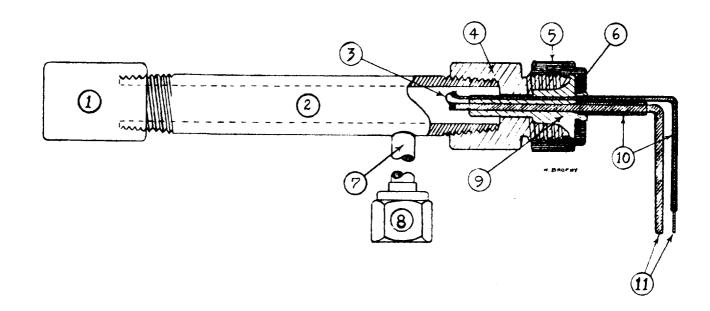
Re-typed May 26, 1972, (original memo used 6 pages) kfq

SHEET NO.

OF .

JOB NO.

SUBJECT



Air Products

- 3000 lb 3/8" F, N. P, T, Cap. 1.
- Yellow Brass Hvy Wall Tube 4" Lg. St. Stl. Resistance Wire 6 to .8 Ω . 3/8" T to 3/8" F. N. P. T. Tylok Fitting.
- 3.
- 4
- 3/8" Tylok Nut 5
- #10 Stl. Washer. 6
- 1/4" O.D. Copper Line . 049" W.T 7.
- 1 4" Tylok Nut. 8
- Teflon Sealant 9
- Wire Insulation. 10.
- 11 Electrode Leads.

BY

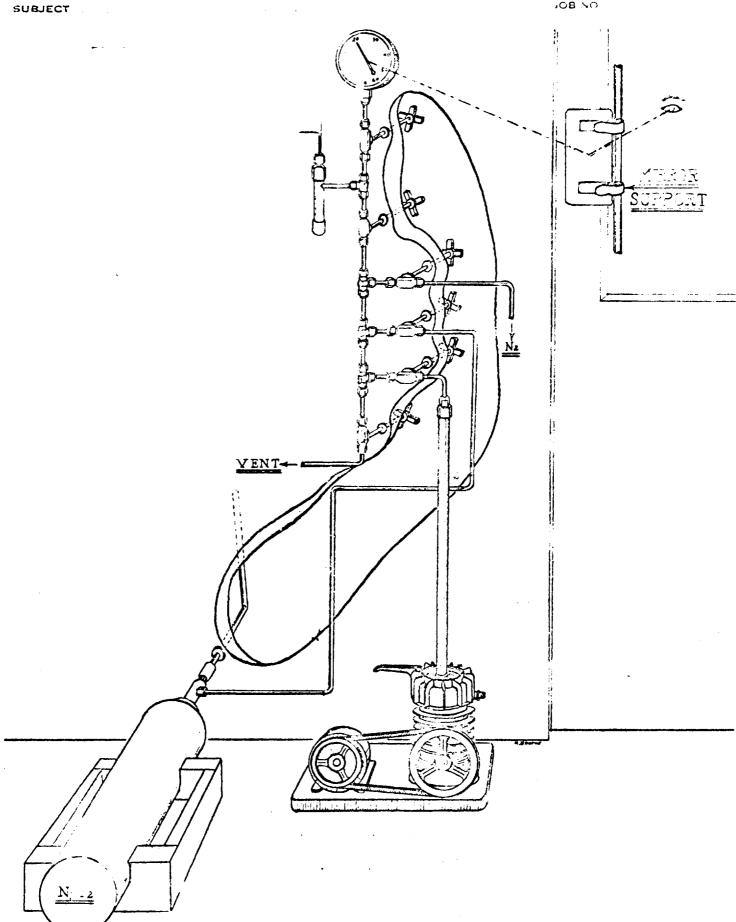
DATE

Air Products

SHEET NO.

OF

708 NO



G. A. Rubens

Assembly of Oxymen Regulators

F. K. Kitson - Safety Dept.

cc:

- J. M. Geist
- C. McKinley

A sample of T-film, manufactured by Eco Manufacturing Company, has been tested for compatibility with oxygen by the Research and Development Department and on the basis of these and other tests T-film is approved for use as a lubricant on threaded connections in the assembly of oxygen regulators. The tests performed were as follows:

1. Oven Test

Sample material in 100 per cent oxygen atmosphere at one atmosphere pressure. Temperature gradually increased to 815°F without ignition. Report dated 9/18/61; laboratory report No. 61-683.

2. Ignition Bomb Test

Six trials were run with oxygen at 2,000 PSIG. No signs of ignition were found in any of the tests. Report dated 11/28/61 E. Kehat to G. Rubens.

This material was also tested for oxygen compatibility by the Douglas Aircraft Company, Santa Monica Division, and reported to withstand 185 ft.-lbs. of impact energy without detonation. This is the maximum capacity of the Santa Monica impact tester. Information was obtained from the Douglas report, Compatibility of Materials with Oxygen, report 081-444.

The usual precautions should be observed when using T-film, wash hands thoroughly before smoking cigerettes or eating.

ORIO	GIN/	AL S	SIGNED	BY
	F.	К.	Kitson	

FKK: jmf

PUT IT IN WRITING

Date: January 28, 1959

TO: W. L. Ball

FROM: E. Dinan

Summarized below are the results of the tests conducted on the various materials you supplied.

1. ABMA (Thread lubricant and sealant)

This black, viscous compound smolders, evolving a black carbon soot, when heated by an open flame. A black smoke continued to rise from the material after the flame was removed; the sample did not support flame. The residue was a gray ash. The material becomes very hard and brittle, but does not fracture when it is placed into a container of liquid nitrogen. This material was non-explosive when placed in liquid oxygen and subjected to the shock of an exploding blasting cap.

2. Anderol L-536 Rust Preventive (Lehigh Chemical Co., Chestertown, Md.)

One sample of this material was tested by concentrating a portion in a beaker on a steam bath and another by applying it to the surface of a beaker and allowing it to air dry.

This material is an emulsion which separates into a three phase liquid on standing. When sprayed into a container of liquid nitrogen, it becomes a milky-white solid. Liquid nitrogen or oxygen cause it to break away from the applied surface and the pieces fracture into small particles. Both samples were burned by an open flame and continued to burn after the flame was removed. The residue was a black liquid. The air-dried sample was non-explosive when tested in liquid oxygen and initiated by a blasting cap.

3. Permacel Ribbon Dope (Permacel, New Brunswick, New Jersey)

This compound is a thin white, flexible tape made of a chemically inert Teflon (DuPont's trademark for its TFE-fluorocarbon resin). It is recommended for a wide range of applications. Seals threaded pipe joints of stainless steel, aluminum, ceramic, galvanized, etc. It is unaffected by oils, gases, organic solvents, refrigerants or corrosive chemicals. It is self-lubricating, stays flexible and won't harden over an extreme temperature range from -320°F to 500°F. When exposed to an open flame, it becomes red and melts. It would not support combustion. Prolonged exposure to fumes at temperatures over 400°F should be avoided.

It showed no marked change in appearance or composition when wrapped around a blasting cap and placed in a container of liquid oxygen for an explosion test. Upon completion of the explosion test, examination indicated no fundamental change had occurred.

This material seems satisfactory for use on both gaseous and liquid oxygen systems.

4. West Concrete Floor Treatment (West Chemical Products, Inc.)

This clear, yellow oil-like liquid becomes a solid with web-like cracks when dropped into liquid nitrogen. It did not fracture. It was burned by an open flame and continued to burn very brightly after the flame was removed, leaving a black ash. The residue formed by evaporating all volatiles was non-explosive when tested in liquid oxygen and initiated by a blasting cap.

5. Al₂0₃

A sample of alumina, which had been used in a drier at Santa Susana, believed to be contaminated with oil, was tested for explosiveness.

This material resembles finely sieved clay and disperses in liquid oxygen to form a uniform emulsion. This emulsion was non-explosive when initiated by a blasting cap. A second sample of the material was placed in a wire mesh basket along with a blasting cap. The assembly was dipped into liquid oxygen contained in the bottom of a glass tube, then raised in the tube and suspended in the gaseous oxygen. A violent explosion of this material was initiated by the blasting cap.

6. Seam Compound (Geon Polyvinylchloride)

This gray, rubber-like plastic can be burned by an open match flame. It briefly supports combustion in air and burns very profusely in gaseous oxygen. It does not retain its elasticity when exposed to the low temperature of liquid nitrogen. It is non-explosive in liquid oxygen.

7. John Crane - Plastic Lead Seal No. 2

This is a thick dark gray compound that solidifies when dropped into liquid nitrogen. It is a flammable compound as received and will support combustion. The residue resembled droplets of yellow coated solder.

This material exploded when it was dispersed in liquid oxygen and initiated by a blasting cap.

ζ	RIG	INAL	SIGNED	BY
	Ε.	Dina	ın	

ed:ph

Air Products, Inc.

PUT IT IN WRITING

TO:	E. R. Lady		Date	December 11, 1959
FROM:	W. L. Ent	SUBJECT	"Putti-ro	pe"; Analysis for
		Oil Conte	ent and Fla	mmability Temperature
	Himmelberger McKinley			
_	e of "putti-rope" which you su and flammability temperature			•
	s indicated the oil content to icated this oil to be of a hyd			Dispersive infra-
The fla	mmability point in a 100% oxyg	en atmospl	here was de	termined to be
			ORIGINAL SIG	GNED BY
			W. L.	Ent

WLE:rsh

PUT IT IN WRITING

Air Produc	ts and Chemicals, Inc.	Date:	July 30, 1963
TO:	A. Mahr	SUBJECT: Gaseous	Oxygen Compatibility
FROM:	R. A. Walde	of Crosslite Fluor	ocarbon Tape

cc: W. L. Ball R. A. Flinn C. McKinley

A sample of a fluorocarbon (Teflon) tape called Crosslite, manufactured by Henry Crossley Ltd. of Bolton, Lancs, England, was submitted for high pressure gaseous oxygen compatibility testing. The tests were run at 2000 psig of oxygen with the sample wrapped around the electrodes supporting the fuse wire igniter. The first two runs gave definite reactions as indicated by detonation and rapid pressure increases. A control test was run in the same manner using a 3-M fluorocarbon tape. This also gave a very violent reaction. A sample of Permacel tape, of the type presently being used in our plant fabrication, was tested and gave a violent reaction. At this point, our system was tested for possible contamination and found to be free of any explosion-causing contaminants.

In an attempt to determine the effect of impurities on the surface of the tape, a sample of the Crosslite material was washed in methylene chloride, dried, and applied to the test system with tweezers so that no finger contact was made. In this instance no reaction occurred. Another sample of tape was washed with methylene chloride, but this time applied by hand and testing resulted in a definite reaction as indicated by an increase in pressure of 1600 psig.

It should be pointed out that variation in the manner in which the sample is applied to the test system has a definite effect on its reactivity. For instance, if the sample is draped over the fuse wire instead of being wrapped around the supporting electrodes, no reaction is observed.

These test results should only be considered as preliminary, since a statistical series was not run, but they do indicate that the tapes themselves are inert in the presence of gaseous oxygen, but will react if their surface is contaminated with any organic matter such as grease that might be applied by handling.

(ORIGINA	٩L	SIGNED	BY
	R.	Α.	Walde	-

RAW: kfd

DATE: 9/18/61 LAB. NO.: 61-600

SAMPLE OF:

T-Film Thread Compound

FROM:

Safety Department

SAMPLING DATE:

REQUESTED BY:

SAMPLED BY:

ANALYSIS REQUESTED:

Flammability in 100% gaseous oxygen

ANALYTICAL METHOD:

ANALYST: L. Y.

IWO NO.: 80-0068

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

IWO IS COMPLETE

ANALYSIS

Sample did <u>not</u> ignite, when heated to a temperature of 815° F in a 100% gaseous oxygen atmosphere.

cc: C. McKinley/W. Ent

E. Lambert

W. Mellick

L. Ball/H. Smith

jlu

D. R. Latshaw C. McKinley W. W. Schmoyer

ANALYTICAL REPORT

DATE: 10/7/70

LAB. NO.: 70-368 - 70-369

LAB BOOK: 1626

SAMPLE OF: Teflon Tape

FROM:

SAMPLING DATE:

REQUESTED BY:

SAMPLED BY:

ANALYSIS REQUESTED:

Percent Ether Extractable Contaminants and Fluorescence

ANALYTICAL METHOD:

Soxhlet Ether Extraction and Ultraviolet Light

ANALYST: L.G.F.

IWO NO .:

XD-0128 PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

250 ml. ether blank = 0.00162 gms.

	Sample Wt. (grams)	Residue (grams)	Percent Ether Extractable Contaminants	Fluorescence
70-368 DAMCO Teflon Tape (by DuPont) 118.25 sq. in.	5.27343	0.01770	0.305	Positive
70-369 SANDEM Industrial Prod. 132.75 sq. in.	5.16233	0.00306	0.028	Positive
70-369-A Crane Packing Co. (by DuPont) 218.25 sq. in.	3.98154	0.00254	0.048	Positive

Percent ether extractable contaminants was calculated by the following method:

$$\% = \frac{\text{Residue - Blank}}{\text{Sample Wt.}} \times 100$$

Sample 70-369-A is the type Teflon tape used at Allentown Labs and was run along as a reference with the other two samples. Sample 70-368 extracted residue contained a white powdery material. The infrared spectrum of this extracted material indicated it was mainly a fluorocarbon compound. The infrared spectrum of the extracted material from Sample 70-369 indicated it was mainly a hydrocarbon.

ORIGINAL SIGNED BY

APCI DOCUMENT

DATE:

1/16/51

LAB. NO.:

60-495, 61-3

.\$

SAMPLE OF: Tape-seal thread lubricant and sealer

FROM:

Safety Department

SAMPLING DATE:

REQUESTED BY:

W. L. Ball

SAMPLED BY:

ANALYSIS REQUESTED: % hydrocarbon contaminant

ANALYTICAL METHOD:

Soxhlet ether extraction

ANALYST: L. Yoder

IWO NO.: 81-0018

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

Lab No.	Sample	Contaminant Content	
60-495	Tape-seal from Friesland Plastic Company	0.21% by weight	
61-3	Permacel Tape from shop at Plant #3	0.40% by weight	
	Permacel Tape from Analytical Lab., Plant #1	0.08% by weight	

cc: W. L. Ball

W. L. Ent

F. Himmelberger

E. Lambert

C. McKinley

W. Mellick

jlm



PUT IT IN WRITING

			Date June 11, 1963	
To	J. Dwyer	Subject_	Gaseous Oxygen Compatibility	
From	R. A. Walde	_	Test on Moly Lube No. 99	
	cc: Ball, L. Flinn, R. A. Geist, J. M. McKinley, C.			
	Five (5) tests were run on a No. 99, MIL-7866 (AER), and of Glen Cove, New York.	n dry MoS ₂ lul manufactured	bricant, coded Moly by Moly Lube Products	
	The five tests were run at a pressure, and gave no reaction under these conditions is consist with previous tests run on Mark with oxygen at these conditions.	on indication	ting that the material hese results contrast	
	At present, it is recommended oxygen service.	ed that this l	Moly Lube be used for	
			ODICINAL CICNED BY	
			ORIGINAL SIGNED BY	

R. A. Walde

RAW:faj

APPROVED PIPE THREAD SEALANTS

PURPOSE 1.

This standard establishes the proper selection and application of approved pipe thread sealants as applied to all Air Products, Incorporated manufactured equipment. The applications of the three types of sealants must be adhered to except where an alternate is required by contract in which case both Safety and Methods Department approval must be obtained.

2. SCOPE

This standard is applicable for liquid and gas service and all conditions of pressure and temperature normally found in our equipment where threaded joints are permitted.

PIPE THREAD SEALANTS

Service	Teflon Tape Permacel 412 Ribbon Dope or Equal (Note 3A)	Leak Lock Sealer or Equal(Note 3B)	Red Lead & Linseed Oil (Notes 3B & 3C)
Acetylene			Х
Air	X		
Ammonia	X		
Argon	X		
Caustic	X		
Ethane			X
Ethylene		<u> </u>	X
Freon		X	
Helium	X		
Hydrogen	X		
Methane			X
Nitrogen	X		
Oil-Lubricating	X	X	
Oxygen	X		
Fropane			Σ
Steam			X
Water	Х		X

3. NOTES:

- Prolonged exposure to temperatures above 400°F should be avoided.
- B. Leak Lock Sealer and Red Lead are preferred for use in any service where their application is permitted.
- C. Common plumbers pipe thread compound.

F. HIMMELBERGER SAFETY DEPARTMENT APPROVAL



FUT IT IN WRITING

Date: October 4, 1963

TO: J. Mills

Subject: Regulatory Thread Sealant

FROM: W. W. Schmoyer

Confirming our telephone conversation of October 3, 1963, you may use <u>Molylube "N"</u> manufactured by Bel-Ray Company, Farmingdale, New Jersey as the thread lubricant on KGM hospital regulators. This material should be used only on these regulators where the plating has reduced clearance of thread joints to make assembly difficult when using Teflon tape.

The material was tested by R & D in February 1963 and is compatible. The material is in limited use in I & M on Paul jumps to correct a seizure problem between stainless and aluminum thread joints.

ORIGINAL SIGNED BY

W. W. Schmoyer

WWS:jmf

IWO 69-075Z 16 Two MOLYLUDE SAMPLES FOR OXYGEN COMPATABILITY TESTS. CHESTNUT HILL 8-4199 Samples rec'd for testing indirectly from WILLIAM SOSNOW INDUSTRIAL REPRESENTATIVE BOX 3055 PHILA. 50 SAMPLES LABELED: B MOLYLUBE N. .. MOLYLUBE KOTE AR BEL-RAY COMPANY, INC. DOSMANTON BEZ-RAY COMPANY, INC. FARMIGDALE, NEW JERSEY SAMPLE DESCRIPTION: Sample a as the ca is opened, sample appears as a very thin, dosh blue liquid. During mixing of the flack sediment with the blush solvent we have a marbelized effect. Completely mind the sample loon its Huish appearance, and becomes a dark silvery grage. Sample & Thick silvery, dark gray material. Mixture wow still a silverygray when mixed throughly. Metial Sample was applied to the bornt walls by pouring sample in some instances there was a shish very where the remaining solvent collected during evaporation. Sample @ was applied with a rod dipped into the sample. and applied to the bornt walls. The materials will be sen on the high-guesare manifold. Sample bomb is attached, and 3 purge cycles consisting of pressurgation to 40 psig No pressure and evacuation. Sample bomb is the pressured with oxygen to the test pressure of 2000 psig. and bomb scaled, with oxygen to the test pressure of 2000 psig. and bomb scaled, remainder of manifold venter. Ignition potential is then applied.

Brown to the second of the seco Bombo were sum in the inverted position. Test Results: Sample & In & of the 6 runs, there was no apparent reaction. In test no. 3, there was a slow increase in pressure of 600 psig, then a total release as the lefton metter. The capsule was very warm to the touch. In test no 5, there was a moderate increase in pressure of tallping. complete release of pressure Capsule was hot to the truck. The more time needed for fall release, allows longer reactor time and pronounced increose in detected heat. An immediate release reaction is usually only 11/4/63 slightly warm, due to the heat dissipition war.

APCI DOCUMEN

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Examination of bomt components of the the testing.

Runs 1,2,46 gave no indication of any reaction.

In the I cases where reaction occurred only a small portion of the sample material was effected. It appears the same in both cases. Natural was furned competely in small areas that were surrounded by a blue rung caused by the concentration of the sample solved evaporating. Several small selver beade were noted possibility of solder. Idelitoral sample gland in an open cup and heated with the oxy acety time torch. Material and not appear to be effected by the heat and appeared uncharged often cooling. The heat of realthing must have melted the solder artificed in factoring the fase-were to the electrotics.

In both cases, the full prevouse release had freed the electrotics from the scalant. 9-6 2 8-4199 PRESENTATIVE T, dosh sample electrotes from the scalant. estrey-Sangh B. In all six test suns there was no apparent reaction to partie of bomb components indicated no evidence of reaction Jan sample It might be significant to note, that in the cleaning of the semi components while preparing for new lists, that the Sample A or Molylike Kite AR was readily solible in Tri-cher, while sample Bitch most appear to the effects by this solvert ld. ressurgation aled, plied. Feb. 63 arent rare of sule was re of holysis The Timo and of. an

DATE:

6/6/61

LAB. NO.: 61-435

SAMPLE OF: Safety Valve Seat "OXOMAT"

FROM:

Engineering Department

SAMPLING DATE:

REQUESTED BY:

N. Stackhouse

SAMPLED BY:

ANALYSIS REQUESTED:

Flammability in 100% gaseous 02.

ANALYTICAL METHOD:

ANALYST: S.R.M.

IWO NO.: 10-0858

PROJ. NO.:

R&D PROJ. NO.:

REMARKS: IWO Completed

ANALYSIS

The sample did not burn, smoke, or flash when heated to 874°F in 100% gaseous oxygen. It did, however, become dry and brittle.

cc: W. Ent

E. Lambert

C. McKinley

W. Mellick

L. Ball

N. Stackhouse

jlm

152 PERMATER SEALANT 1516 COMPATABILITY TESTS WITH HIGH PRESSURE OXYGEN
TO ME PERMATER SEALANT 1316 COMPATABLETT VILLE
MAG. PERMATEX COMPANY, INC FOR OXYGEN ASSEMBLIES-
MAG. PERMATEX COMPANY, INC FOR OXYGEN ASSEMBLIES - BROOKLN 35, N.Y. Use on threshed, flot, or flonge surfaces.
KANSAS COTY 15, KAN.
·
Directions. Apply in a thin layer about the thickness of an oraning business card. Allow to vecome tacky before assembling.
card. allow to vecome tacky before assembling.
.5 gram samples were aportioned to each of six reactor tomber, numbers 13 though 18, and allowed to air dry. Bombs were then assembled in gregaration for ignition.
.5 gram samples were aportioned to lack of sex mater women, all in
13 though 18, and allowed to air dry. Donnto will war beauty
preparation for ignition.
2 1. 1. Of a high pressure manifold 3 surge
Samples closed individually or high pressure manifeld 3 junger yelles sun and pressurged to 20000519 oxygen. Ignition soluted was then applied.
yoles sun, and presented to
was then appelled.
I to six testo made there was no apparent reaction.
Farming tion of reator, componente also indicated no reaction, with
In the six testo made there was no apparent reaction. Examination of reactor components also indicated no reaction, with the sample appearing unchanged.
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M. Brothy 1-13

,006.5g

(%)

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P8600.

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7.7110

7.7170

7.7110

7.7045

MOLLY "99" COMPNIABILITY TESTS WAN HIGH PRESSURE OXYGEN ML-L-7866 (AFR MOLYBOENUM DISULFIDE DRY LUBRICANT ,66, KTOW SAMPLE LABELED

MFG. BY MOLY KUDRICATION PRODUCTS GLEN COVE, N.Y. with swat Grand 1 take wall souder.

Wr & Drsw & Sample 7.74365.

7.7436 7.7382 7.7382 7.7382 (3) .0054 (3) .0054 (4) .00719 (6) .0063 5

(a) . 0054 (b) .0071

©,0063 ©,0078

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0000 0

" was diens saysaule lecked at acalant and Under ties and tried

APCI DOCUMENT NO. 99000/23

MAY 26, 1964

NASA TM X-53052

COMPATIBILITY OF MATERIALS

by C. F. KEY
Propulsion and Vehicle Engineering Laboratory

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

November 3, 1966

VASA TM X-53533

COMPATIBILITY OF MATERIALS WITH LIQUID OXYGEN, III

By C. F. Key
Propulsion and Vehicle Engineering Laboratory

SPECIAL RELEASE-

Not to be indexed, referenced, or given further distribution without approval of NASA.

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

FOR INTERNAL U.S. GOVERNMENT USE ONLY

August 23, 1968

WASA TM X-53773

COMPATIBILITY OF MATERIALS WITH LIQUID OXYGEN, IV

By C. F. Key
Propulsion and Vehicle Engineering Laboratory

SPECIAL RELEASE-

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NASA

George C. Marshall Space Flight Center Huntsville, Alabama

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MASA TECHNICAL MEDIMINANDUM



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August 1964

SPECIAL RELEASE

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COMPATIBILITY OF MATERIALS WITH LIQUID OXYGEN

by C. F. Key and W. A. Riehl

George C. Marshall Space Flight Cemer

Huntsville, Ala.

FOR INTERNAL U. S. GOVERNMENT USE CHLY

MTP-P&VE-M-63-14 December 4, 1963 (Supersedes MTP-P&VE-M-63-14 dated October 23, 1963)

GEONGE C. W.

SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

COMPATIBILITY OF
MATERIALS WITH LIQUID OXYGEN

By

C. F. Key and W. A. Riehl

FOR INTERNAL USE ONLY

APCI DOCUMENT

MSC-02681 SUPERSEDES: MSC-NA-D-68-1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NONMETALLIC MATERIALS
DESIGN GUIDELINES AND
TEST DATA HANDBOOK

NOTICE C

THIS DOCUMENT IS AN UPDATE OF THE REVIEW COPY PROVIDED FOR THE "NASA CONFERENCE ON MATERIALS FOR IMPROVED FIRE SAFETY" ON MAY 6-7, 1970.

THE DOCUMENT IS REVISED PERIODICALLY.

IT IS A WORKING DOCUMENT USED BY NASA AND ITS CONTRACTORS TO RAPIDLY DISSEMINATE NONMETALLIC MATERIALS FLAMMABILITY AND OFFGASSING DATA, AND RELATED DESIGN INFORMATION.



RELIABILITY AND QUALITY ASSURANCE OFFICE
MANNED SPACECRAFT CENTER

HOUSTON, TEXAS May 29, 1970

DATE:

2/3/61

LAB. NO.: 61-34 00 61-40

incl. and 61-42

SAMPLE OF:

Sealing Materials

FROM:

Engineering Department

SAMPLING DATE:

REQUESTED BY:

B. W. Taylor

SAMPLED BY:

ANALYSIS REQUESTED:

Flammability in 100% gaseous oxygen.

ANALYTICAL METHOD:

ANALYST: L. Yoder

IWO NO .:

10-0589

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

Lab. No.	Sample	Result
61-34	Foamseal 30-45-liquid state	Ignited at 650°F
61-35	Foamseal 30-45-dry state (Main State)	Ignited at 660°F
61-36	Flexfas 82-10-liquid state	Ignited at 675°F
61-37	Flexfas 82-10-dry state	Ignited at 605°F
61-38	Sealfas mastic 31-97-liq. state	Did not ignite, but was oxidized at 1000°F.
61-39	Sealfas mastic 31-97-dry state	Did not ignite, but was oxidized at 1000°F.
61-40	Pittseal III-Liquid state.	Ignited at 715°F
61-42	Porous insulating material (Foam Glass)	The insulating material did not ignite and was not affected in any way at a temp. of 925°F. However, the material used to laminate the two porous pieces ignited at 715°F and was highly flammable.

cc: L. Ball

W. Ent

E. Lambert

C. McKinley

W. Mellick

B. W. Taylor

jlm



QUALITY CONTROL LAYOUT

Number : Effective:

QCL 103L 7/1/71

Page:

1 of 2

Supersedes:

10/12/62

PROCEDURE TO ESTABLISH ACCEPTANCE OF FIBERIZED MINERAL WOOL INSULATION

I. PURPOSE

To list the procedure to be used to determine the acceptance of fiberized mineral wool purchased with limited contamination level.

II. PROCEDURE

- A. A lot will be determined acceptable by sampling in accordance with Quality Control procedure Q208. The number of unit packages in a shipment will establish the lot size.
- B. The samples (each sample to be a handful equivalent) shall be taken at random from various parts of a shipment. The package of material from which a sample is obtained shall be determined commercially free of pellets, needles, slag dust, trim from board insulation, and other impurities.
- C. Each sample shall be identified with the Purchase Order number and the lot number which it represents. The lot shall be identified, with the lot number and Purchase Order number, and held pending the result of the sample analysis.
- D. Each sample shall be packaged separately, but all samples of one lot
- shall be grouped together and analy.

 a. Samples will be submitted to the Research & Develthru the Inspection Department.

 b. A copy of the Material Transfer Request (Form 1160) shall be forwarded to Quality Control.



QUALITY CONTROL LAYOUT

Number:

QCL 103L

Effective:

7/1/71

Page: Supersedes:

2 of 2 10/12/62

PROCEDURE TO ESTABLISH ACCEPTANCE OF FIBERIZED MINERAL WOOL INSULATION

E. The samples shall be analyzed by the Soxhlet (ether) extraction method, and by ultra-violet inspection of the extracted residue. The oil content shall not exceed .175% by weight.

F. Based on the results of analysis, Inspection will determine acceptance and release material for use.



PUT IT IN WRITING

Date: 17, 1963

TO: J. Mills

Subject: Kel-F High Pressure Oxygen

Compatibility

FROM: R. A. Walde

Six tests were run on samples of shredded Kel-F polymer. These tests resulted in three reactions out of five samples, as indicated by increase in pressure and temperature upon ignition. These results were questioned due to possible sample contamination. For this reason the tests were re-run, washing the shredded Kel-F with methylene chloride three times prior to charging to the test bomb. For comparative purposes, six samples of nylon were also prepared in the same manner.

The tests were run at 2000 pounds oxygen pressure using 0.5 grams of sample. The Kel-F gave six reactions out of six tests, as indicated by a pressure increase to 4000 pounds plus. Only two nylon samples were run since a violent detonation occurred in each case causing damage to the testing bomb.

The results of these tests indicate that while the Kel-F is not completely inert in the presence of oxygen, it is considerably safer than nylon for oxygen service equipment.

ORIGINAL SIGNED BY

R. A. Walde

RAW:faj

cc: Ball, L. Flinn, R. A.

McKinley, C.

DATE: 1/6/61 LAB. NO.: 60-496

SAMPLE OF: Nylon seat used in K-G regulator

FROM:

Safety Department

SAMPLING DATE:

REQUESTED BY: W. L. Ball

SAMPLED BY:

ANALYSIS REQUESTED: Ignition temperature in 100% oxygen atmosphere

ANALYTICAL METHOD: Flammability test apparatus in 100% Oxygen Atmosphere

ANALYST: L. Yoder

IWO NO.: 81-0017

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

The nylon seat ignited at 840° F, and burned until it was completely consumed. At 725° F the material became soft and gummy and bubbled as though it were boiling.

cc: W. L. Ball

W. L. Ent

F. Himmelberger

E. Lambert

C. McKinley

W. Mellick

jlm

3

AIR PRODUCTS AND CHEMICALS, INC. RESEARCH AND DEVELOPMENT DEPARTMENT

BEHAVIOR OF TRANSITE UNDER COMPRESSIVE LOADS AT AMBIENT AND LIQUID NITROGEN TEMPERATURES

Edmund G. Bauer

August 1962

Technical Report No. 53

IWO 10-1370

Distribution:	C. Anderson	M. Jester
	J. Arnold	E. Kurzinski
	W. Bain	A. Lapin
	L. Ball	C. McKinley
	R. Campbell	L. Pool
	L. Claitor	C. Schilling
	J. Cost	N. Simon
	D. Cummings	J. Stewart
	E. Donley	B. Wobker
	F. Eastman	K. Zeitz
	R. Flinn	
	L. Gaumer	D. Haker (APL)
	J. Geist	J. Graeffe (APL)
	T. Gresham	, ,
		L. Von Szeszich

ABSTRACT

Non-flammable materials are being sought to replace wooden support members used in the Air Products' cold-boxes. Transite, a cement-asbestos fiber product, is an economical replacement; however, no data were available on its compressive strength at liquid nitrogen temperatures. This program was initiated to determine safe working stresses of Transite loaded at ambient temperature and cooled to -320°F.

Three types of specimens were prepared: partial surface loaded, total surface loaded, and yoke-type support.

This study showed that the safe compressive working stress of Transite was 1320 psi at ambient temperature and 1000 psi at -320°F. It was shown that in yoke-type applications thickness should be at least 3 1/4 inches, and in uniformly distributed surface loads, thickness should be at least two inches.

TABLE OF CONTENTS

ABSTRACT	. 1
TABLE OF CONTENTS	. ii
LIST OF FIGURES	.iii
LIST OF TABLES	.iii
INTRODUCTION	. 1
APPARATUS AND TEST PROCEDURE	. 2
DISCUSSION OF RESULTS	. 9
CONCLUSIONS AND RECOMMENDATIONS	. 13
APPENDIX	. 16

LIST OF FIGURES

Figure		Page
1	Schematic Diagram of Transite Test Apparatus	2
2	Test Apparatus	3
3	Cold-Box and Nitrogen-Powered Motor	3
4	Cold-Box and Specimen	4
5	Schematic Diagram of Cold-Box	4
6	Totally Loaded Specimen	5
7	Partially Loaded Specimen	6
8	Yoke-Type Specimen	7
9	Location of Thermocouple	8
10	Cracked Specimen	9
11	Significant Yoke Dimensions	14
12	Water Absorption Characteristics of Transite, Specimen No. 3	15
A-1	Loading Characteristic of Transite Test Apparatus Bellows Cylinder No. A232844	17
A- 2	Loading Characteristic of Transite Test Apparatus Bellows Cylinder No. A232844	18
A-3	Loading Characteristic of Transite Test Apparatus Bellows Cylinder No. A232844	19
A- 4	Loading Characteristic of Transite Test Apparatus Bellows Cylinder No. A232844	20
	LIST OF TABLES	
I	Results of Transite Testing	10

INTRODUCTION

Wooden support members in Air Products' cold-boxes constitute a fire hazard; therefore a suitable non-flammable substitute is being sought. Transite is considered the most economical replacement. A test program was initiated to observe the behavior of Transite when loaded as an equipment supporting member, and to specify safe loading stresses for the various support members when used at ambient temperature and -320°F.

Transite is a composition of Portland cement and asbestos fibers. It is manufactured by pressing the water out of a slurry of cement and asbestos. The fibers have no preferred orientation and therefore the strength of the material is uniform in all directions. The following properties were furnished by the manufacturer.

Maximum service temperature	600°F
Normal moisture content	5 to 13 %
Coefficient of thermal expansion (ambient to 400°F)	5.0 x 10 ⁻⁶ in./in. °F
Density	100 lb/ft ³

The following strengths apply only to ambient temperature:

Tensile fracture	1400	psi
Shear strength		
1/4-in. thickness	4000	p si
3/8 to 7/8-in. thickness	3500	psi
over 7/8-in. thickness	3000	psi
Transverse modulus of rupture		
1/4-in. thickness	4500	psi
3/8 to 7/8-in. thickness	4000	psi
over 7/8-in. thickness	3500	psi

Transite is available as corrugated sheets, flat sheets, and pipes. The maximum flat sheet thickness is four inches.

^{*}Transite - Johns-Manville, Inc., Philadelphia, Pennsylvania

APPARATUS AND TEST PROCEDURE

A. Apparatus

The testing apparatus is shown schematically in Figures 1 and 5. Photographs of the equipment are presented in Figures 2, 3, and 4.

- 1. Nitrogen driven motor Bellows-Valveair Air Cylinder No. 6006RFRC, Serial No. A232844, 200 psi maximum pressure, 6-inch bore x 6-inch stroke.
- 2. P-1 Heise gage No. HlC268R, O to 600-psi range, 1/2-psi increments.
- Deflection gage Federal Dial Indicator C81S, 0 to 1-inch range,
 0.001-inch increments.
- 4. Potentiometer APCI Tech Instrument 4-16, Minneapolis-Honeywell No. 2745.

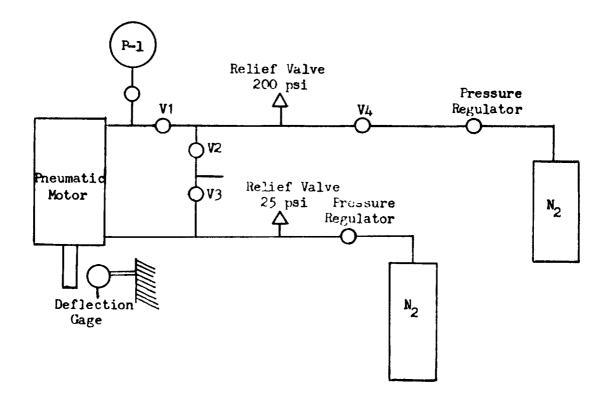


FIGURE 1 - SCHEMATIC DIAGRAM OF TRANSITE TEST APPARATUS

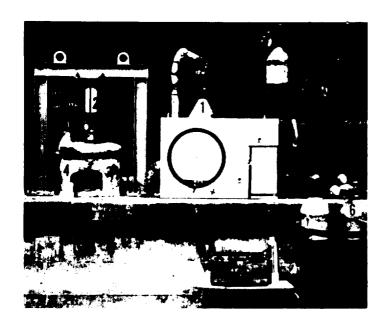


FIGURE 2 - TEST APPARATUS

- 1 Liquid nitrogen storage
- 2 Nitrogen powered piston and cylinder
- 3 Deflection gage
- 4 Cold-box
- 5 Potentiometer
- 6 Nitrogen for activating piston

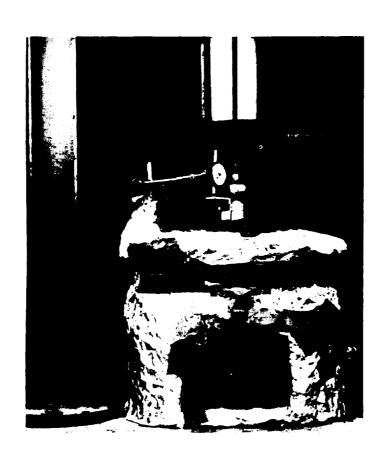
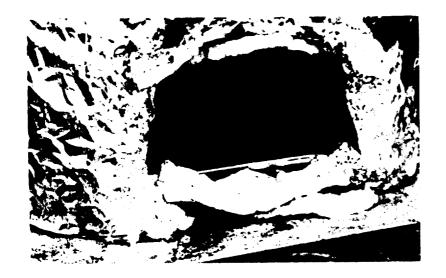


FIGURE 3 - COLD-BOX AND NITROGEN-POWERED MOTOR



- 1 Spacer blocks
- 2 Transite specimen

FIGURE 4 - COLD-BOX AND SPECIMEN

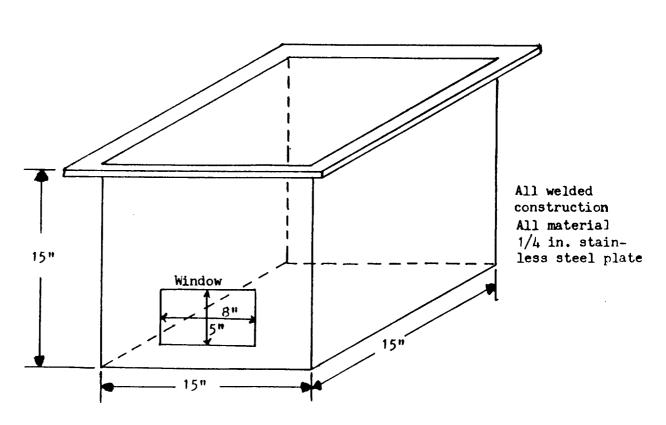
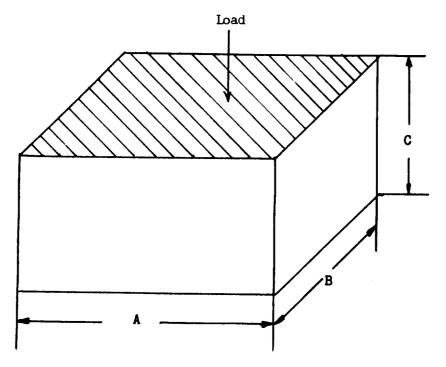


FIGURE 5 - SCHEMATIC DIAGRAM OF COLD-BOX

B. Specimens Tested

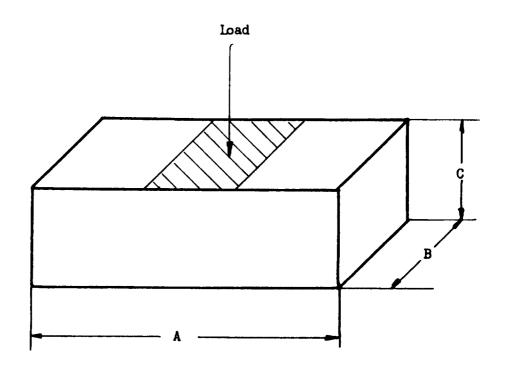
Sketches of the several types of test specimens are shown in Figures 6, 7, and 8.



DIMENSIONS

Specimen	A	В	С
1-A & 1-B	3"	2"	2"
11, 12, 13	1 1/2"	1 1/2"	2"

FIGURE 6 - TOTALLY LOADED SPECIMEN

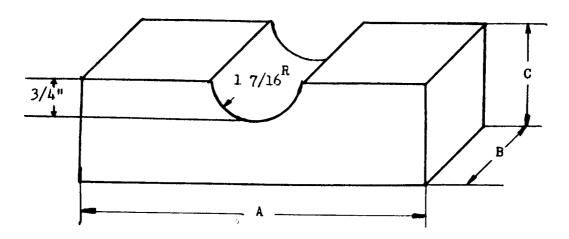


DIMENSIONS

Specimen	A	В	С	Load Area (sq. in.)		
2, 3, 4, 5, 6, 7, 8	6"	2"	2"	4.1		
9, 10	6#	1 5/8"	2"	1.680		

FIGURE 7 - PARTIALLY LOADED SPECIMEN

Surface of the yoke was a bandsaw finish



DIMENSIONS

Specimen	A	В	C
5 *	6"	2"	2"
14, 15	6"	1 5/8"	2"
16	6"	2"	4"

FIGURE 8 - YOKE-TYPE SPECIMEN

^{*}Specimen No. 5 was prepared and loaded as shown in Figures 7 and 8 respectively.

C. Test Procedure

The loading system was calibrated as shown graphically in Figures A-1 through A-4 in the Appendix. Ram force was measured with American Scale Company balance No. 69.

The specimens were placed into the cold-box at ambient temperatures and loaded to the desired stress. Load and deflection readings were taken at 600 lb_F intervals between zero and 100% of load. When the desired stress was attained, the load was removed and the specimen was examined for cracks. The specimen was then reloaded and cold nitrogen was admitted to the cold-box. For slow cool-down, the gas was vaporized in the transfer line and then contacted with the specimen. A shielded thermocouple was embedded horizontally into the Transite as shown in Figure 9. Temperature, load, and deflection readings were taken at five-minute intervals until the specimen was cooled to -320°F. For rapid cool-down, liquid nitrogen was directly contacted with the specimen. The liquid level was maintained 1/4 inch above the face of the specimen.

When the specimen reached -320°F, the cold nitrogen supply was shut off. The loaded specimen was allowed to warm up slowly by natural heat leak. When the specimen was warmed to ambient temperature, it was removed and checked for cracks.

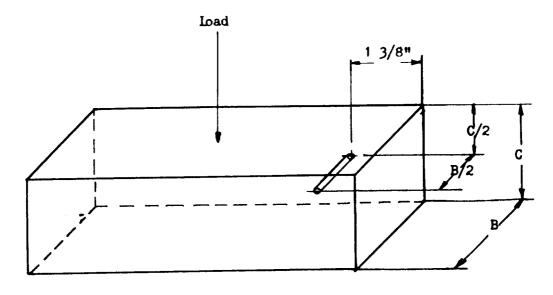


FIGURE 9 - LOCATION OF THERMOCOUPLE

DISCUSSION OF RESULTS

The data and an analysis of the results are summarized in Table I. Twentynine tests were performed on specimens of the configurations shown previously
in Figures 6, 7, and 8. None of the specimens failed when loaded to 1000 psi
at ambient temperatures. Specimen Nos. 6 and 8, which were in the "as received"
condition, cracked when thermally cycled under load. The location of the hairline crack in both instances is shown in Figure 10.

Specimen No. 6 was recycled twice, and the crack propagated 7/8 inch on the front and rear face. The width of the crack did not change appreciably, and the specimen retained much of its strength.

Specimen No. 4 was saturated with water and immersed into liquid nitrogen. No cracks were produced. The cold specimen was then loaded to 1000 psi and no cracks were noted. The cold specimen was reloaded and allowed to warm up slowly under load. Upon removal, the specimen was cracked similarly to specimen Nos. 6 and 8. Two recycles propagated the crack; however, the width of the crack did not change appreciably. None of the cracked recycled specimens was found broken in half.

Specimen No. 7 was cycled seven times; no cracks were found. The rate of cool-down was found to have no influence upon the strength of the material.

Specimen Nos. 9 and 10 were cycled five times without removing the load; no cracks were found.

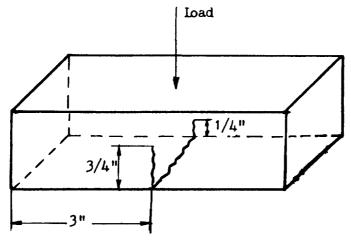


FIGURE 10 - CRACKED SPECIMEN

TABLE I = RESULTS OF TRANSITE TESTING

Remarks		Completely stressed. Top and bottom faces lined with pressure sensitive tape. Fast cool-down.	Fast cool-down. Fast recycle	Piece No. 1 cut in half to obtain 1A. Loaded over entire face.	Loaded 90° from previous day.		Two yoke-type specimens simultaneously loaded.		Four layers pressure sensitive tape on loading face.
Condition After Test		intact	intact	intact	intact		both cracked	intact	cracked
Lowest Condition Temperature After Test	SPECIMEN	-320	-320	-320	-320	EN	-350	-320	-320
Material Condition	Ω	as recvd.	as recvd.	as recvd.	as recvd.	SPECIMEN	as recvd.	as recvd.	as recvd.
Minimum "C" Dimension	I LOADE	~	ĸ	74	7	S-TYPE	1 1/4	3 1/4	1/4
Stress P	TOTALLY	2000	1980	278	278	YOKE	632 plane 515 curve	975 plane 800 curve	792 plane 650 curve
Load Area in ²		2.25	2.25	90.9	9.00		4.1 plane	4.1 plane	5.05 plane
Load 1b _F		0877	0977	5080	5080		5180 total	4010	0007
Specimen Number		=		Y- 4	1		14 & 15	91	~

TABLE I - RESULTS OF TRANSITE TESTING (Continued)

Remarks		Cut as shown in Figure 7.	"C" was sheet thickness.		Specimen reloaded immediately after previous test and allowed to warm up under load	Slow cool-down.	Slow cool-down.	First recycle. Slow cool-down.	Second recycle. Fast cool-down.	Third recycle. Fast cool-down.	Fourth recycle. Fast cool-down.	Fifth recycle, Medium cool-down.	First recycle. Slow cool-down. Crack propagated but piece did not halve.	Second recycle. Fast cool-down. More pro- pagation.
Condition After Test	N	intact	intact	intact	cracked	cracked	intact	intact	intact	intact	intact	intact	cracked	cracked
Lowest Temperature	PECIMEN	ambient	ambient	-320	-320	-320	-320	-320	-320	-254	-308	-320	-195	-320
Material Condition	S Q I Q	as recvd.	as recvd.	sat. H ₂ 0 & cooled	sat. H ₂ O & cooled	as recvd.	as recvd.	as recvd.	as recvd.	as recvd.	as recvd.	as recvd.	exposed to ambient conditions after init.	exposed to amb. cond. after init. treatment
Minimum "C" Dimension	LLY LOA	8	8	ď	ત	8	N	74	N	01	N	CV	ત	N
Stress	ARTIA	1320	1325	1320	1038	975	375	975	975	975	975	975	975	975
Load Area in ²	d	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Load 1b _F		5430	5450	5430	7560	0007	0007	0007	0007	0007	0007	0007	000†	0007
Specimen Number		2	ν.	7	4	9	7	2	7	7	2	7	4	4

TABLE I - RESULTS OF TRANSITE TESTING (Continued)

Remarks		Fast cool-down.	First recycle. Fast cool-down. Crack propagation but did not halve.	Second recycle. Fast col-down.	First double loading.	Two specimens simultaneously loaded.	
Condition After Test	7	cracked	cracked	cracked	intact	intact	intact
Lowest Condition Temperature After Test	SPECIMEN	-320	-320	-320	-320	-320	-320
~		as recvd.	as recvd.	as recvd.	as recvd.	as recvd.	sat. H ₂ 0
Minimum "C" Material Dimension Condition	IALLY LOADED	8	8	~	~	7	1
Stress psi	PARTIA	975	972	1000	576	1015	0
Load Load Area Stress lb _F in ² psi	a.	4.10	4.10	4.10	1.68	2.44 each	-
Load 1b _F	 !	0007	3990	4010	3270 total	4960 total	0
Specimen Number		∞	9	9	9 & 10	9 & 10	m

CONCIUSIONS AND RECOMMENDATIONS

At ambient temperatures, compressive stresses of 1320 psi may safely be placed upon the Transite. For use at temperatures to -320°F, the following recommendations are made:

For support members cut from 2-inch thick sheets and loaded across an entire surface (Figure 6) compressive stresses of 1000 psi may be safely applied.

For a yoke-type support (Figure 8) the X dimension (see Figure 11) should not be less than 3 1/4 inches for compressive stresses up to 1000 psi based on the Y-B area. Pressure-sensitive soft plastic tape which was used as a load distributor was not effective in preventing a specimen from cracking.

For members having the stress applied over a flat portion of the total surface (Figure 7) a compressive stress of 1000 psi may be safely applied.

The compressive stresses indicated above represent the maximum stresses that were applied on the test specimens during testing, and do not represent actual maximum safe stresses for the material. If higher stresses are required, it is recommended that additional testing be performed to determine higher safe stress values. The stresses applied to the test specimens were limited by the safe working pressures of the pneumatic motor and by minimum meaningful specimen dimensions.

Where the recommended dimensions cannot be maintained because of space limitations, a stainless steel back-up strip should be used to reinforce the Transite. It may also be advisable to consider Transite reinforced with a screen mesh. The manufacturer can provide a m sh-reinforced sheet 2 inches x 48 inches x 96 inches for approximately \$100.

)

The moisture content of Transite becomes significant when the material is used at low temperatures. It is recommended that the Transite have a moisture content of less than 8%. Saturated Transite contains 12 to 13% water. Figure 12 illustrates that the material can become 80% saturated when soaked for only five hours. Therefore, Transite which is used for cold-box service should be stored in an area protected from rain.

It should also be noted that the thermal conductivity of Transite is 0.43 Btu/hr.ft^{2 o}F/ft compared with 0.11 Btu/hr.ft^{2 o}F/ft for maple wood. Provisions should be made to prevent the potential increase in heat leak where the Transite is in proximity with the cold-box.

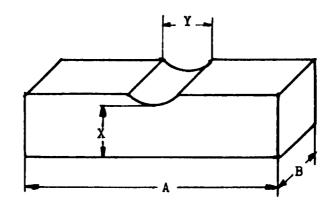
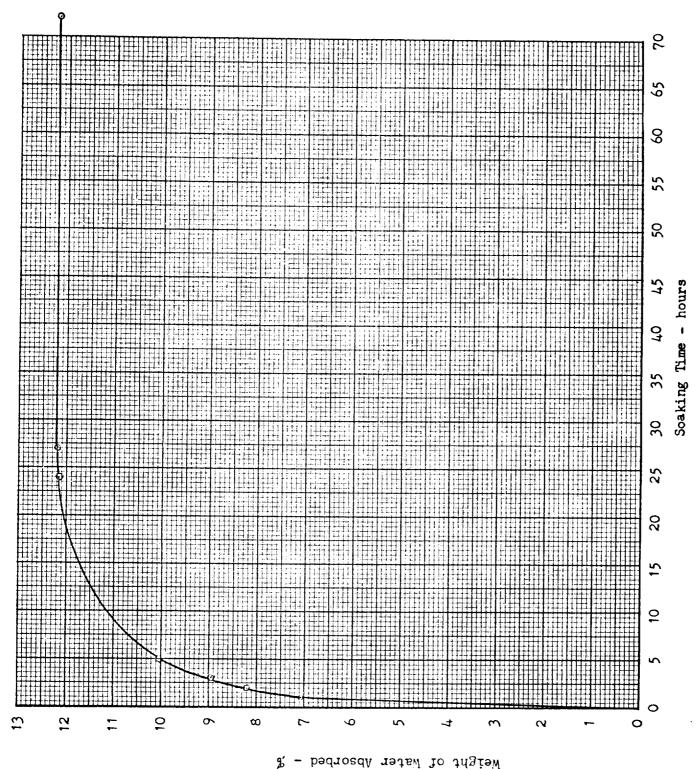


FIGURE 11 - SIGNIFICANT YOKE DIMENSIONS

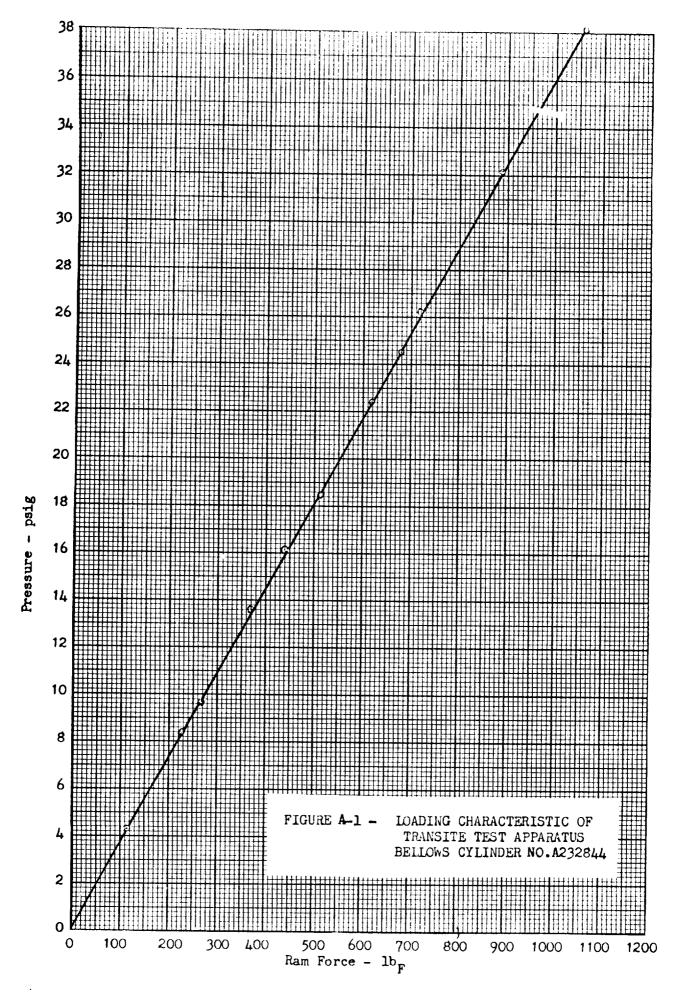
REFERENCE

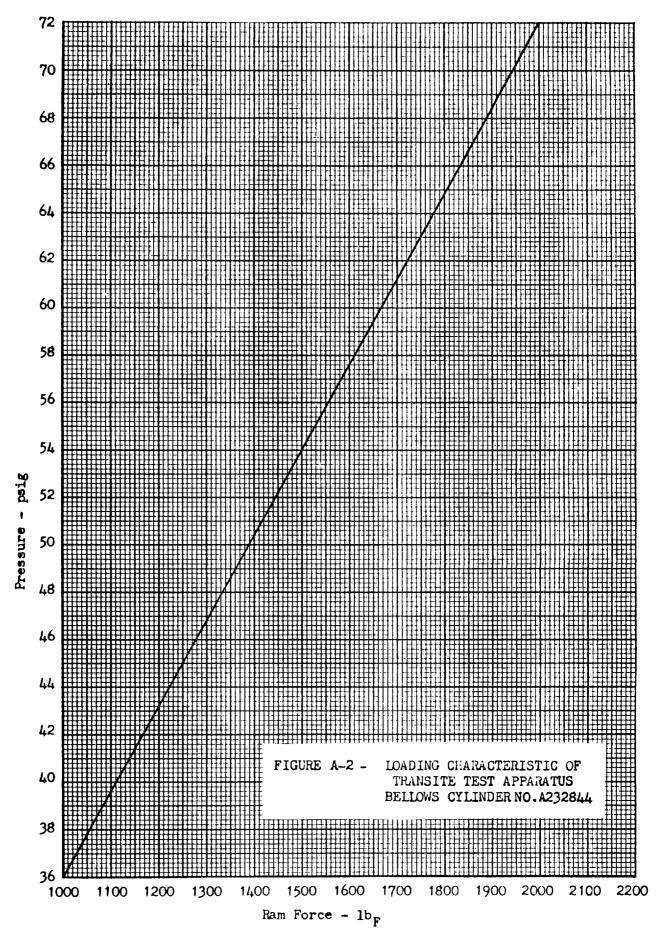
Air Products and Chemicals, Inc. Design and Computation Book No. 1060, April 12, 1962.

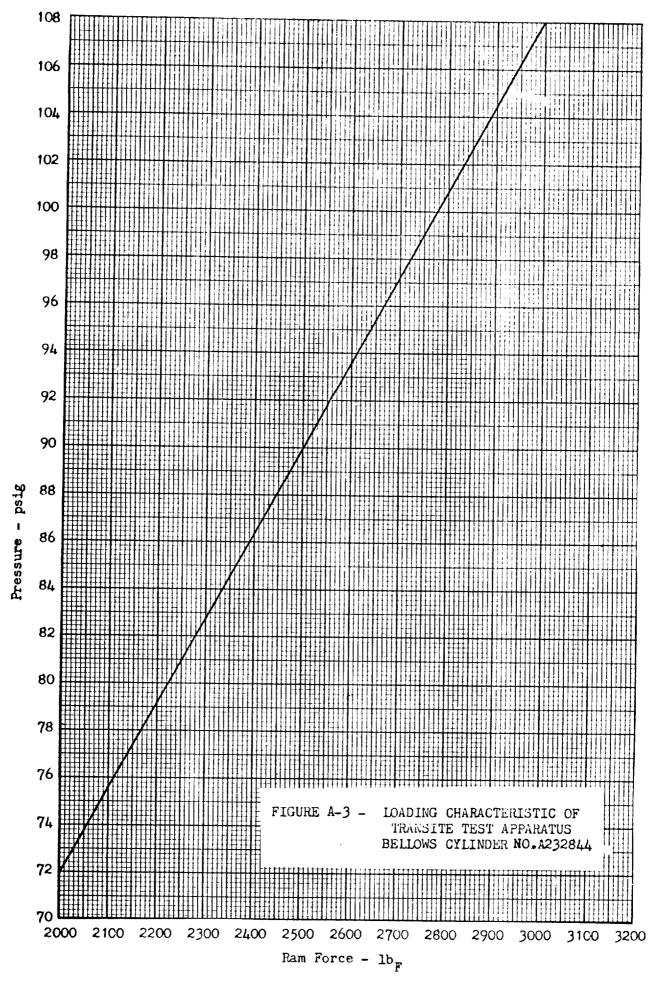


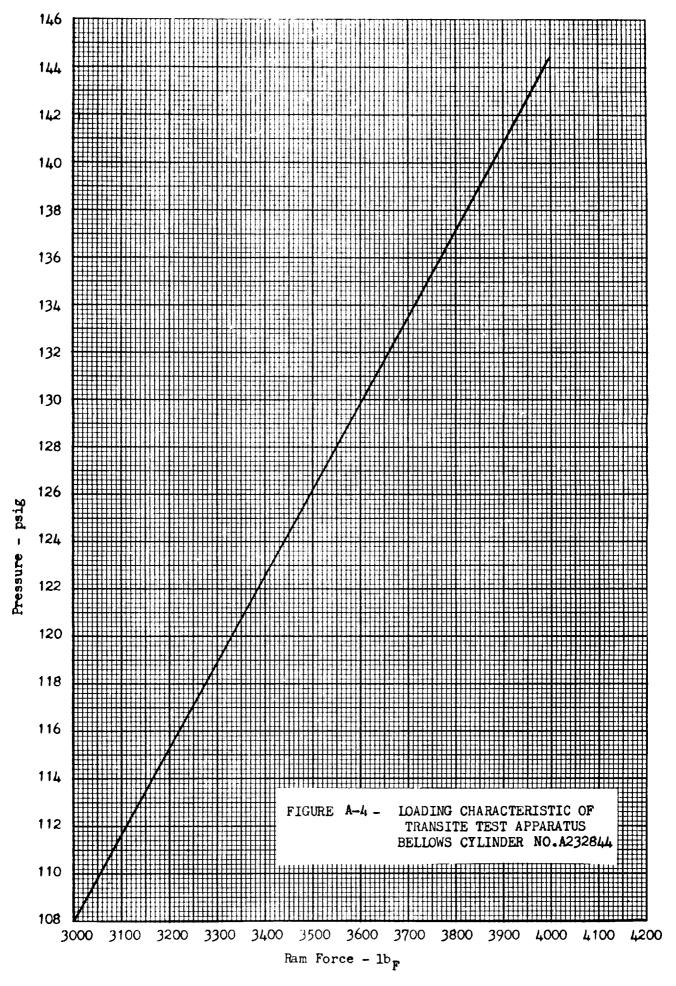
WATER ABSORPTION CHARACTERISTICS OF TRANSITE, SPECIMEN NO.

APPENDIX











PUT IT IN WRITING

Date: April 27, 1966

TO: W. W. Schmoyer SUBJECT: Safety Tests under WO 81-0095

FROM: M. Brophy

Copy to: G. E. Schmauch

As per your request, Hylomar Universal Jointing Compound, SQ-32, and Viton "A" gasket materials were subjected to the following compatibility tests.

Hylomar Compound, a blue transparent, gel-like material was subjected to an oxygen atmosphere oven test. Sample was heated up to 610°F with little change, other than darkening of the material. At a slight increase in oxygen pressure, (less than two atmospheres) the sample burst into flame. Reaction was not surprising, as the material in its original form had a very strong solvent odor present.

Instructions for the material's use indicated a waiting period prior to assembly of components to allow solvent to evaporate. In practical shop utilization this waiting period might easily be overlooked in rush shipments. With the above test results in mind, this material would not be considered as oxygen compatible.

The Viton "A" material was to be tested for compatibility with 250 psig oxygen pressure. Three bombs were processed as requested. In three tests there was no apparent reaction substantiated, either during initiation or in the post test component examinations. Viewing material under the test conditions it was subjected to, it appears to be an oxygen-compatible material.

ORIGINAL SIGNED BY

M. Brophy

MB:mes

	•	



PUT IT IN WRITING

Date: January 3, 1962

TO: C. McKinley

Subject: Development of Standard Ignition

Test. Progress Report - Project

No. 87-0-8821

Ball, L. Foster, P. Geist, J. M.

E. Kehat

ABSTRACT

F'ROM:

cc:

The sensitivity tests of the "standard" ignition test are described and are compared with data from LOX impact testers. This test is more sensitive than LOX impact testers. Attempts will be made to develop this method for use at LOX temperatures.

INTRODUCTION

This note is a second interim report on the development of the Standard Ignition Test (see note: November 17, 1961). The first note described in detail the equipment, procedure, and the effect of surface concentration on the sensitivity of the test. The results indicated that with 0.25 cc samples at 2000 psig oxygen pressure, reproducible results are obtained. For highly volatile materials (methlene chloride, chloroform) 0.5 - 1 cc. samples were used to make up for evaporation losses, before the test.

The materials tested in this series of tests were chlorinated solvents that required relatively high impacts to detonate in LOX, in impact testers.

One change in procedure was introduced. The pressure bombs are ignited in an inverted position with the ignitor at the low end.

RESULTS

The materials tested in order of sensitivity were: methylene chloride; 1,1, dichloroethane; 1,1,1, trichloroethane; trichlorethylene; carbon tetrachloride; chloroform.

An attempt was made to define the sensitibity of these materials numerically by defining numerically the ignition behavior in each test and averaging these numerical values for all the tests with the same material.

Heating up of the bomb and the condition of the residue give only an indication that ignition occurred. However, observations of the pressure in the bomb upon ignition, under the same conditions of bomb volume and area, amount of sample, and oxygen pressure, show a marked variety of behavior that is a function of the sensitivity of the material being tested.

The flowing numerical values were assigned:

- 5 Detonation. Immediate high pressure rise, pressure release or gage pegging.
- 4 Fast pressure rise. Pressure rises to releif value in 3 7 seconds.
- 3 Slow ignition. Pressure rises considerably, but slower.
- 2 Limited reaction. Pressure rises slightly, or slight heating of bomb.
- 0 No signs of ignition.

In these 36 runs there was one case of bomb failure due to oxygen leak and one no ignition test for 1,1,trichloroethane that was attributed to bomb failure, without any visible evidence, only because it seemed unlikely that a relatively sensitive material would fail to ignite.

TABLE I
RESULTS OF THE SENSITIVITY TESTS

Γ				Result	s of I	ndivid	al Tes	ts	
	Material	Sensitivity	<u> </u>	Bomb Failure	5	14	3	2	0
IA7a-6 IA7a-1 IA7a-2 IA7a-3 IA7a-4 IA7a-5	Methylene Chloride 1,1, dichloroethane 1,1,1, trichloroethane Chloroform Carbon Tetrachloride Trichlorethylene	4.6 4.0 4.0 1.5 2.3 2.3		1 (1)	3	2 6 5 1 2	3 4 2	1	3 1 1

The sensitivity of these materials and the distribution of the individual tests are given in Table I.

COMPARISON OF RESULTS WITH LOX IMPACT TESTS

The results of our tests are compared below with results of impact tests of the same materials with LOX, made by different laboratories. The impact tests data are given in the form of the impact energy level in ft-lb and the number of ignitions out of the number of tests.

TABLE II

COMPARISON OF OUR TESTS WITH LOX IMPACT TESTS

	Material	Our Tests	(1)	(2)	(3)
IA7a−6	Methylene Chloride (Reagent Grade per M. Brophy 6/4/62)	4.6	148-0/10	180-0/10	170-0/10 18u~2/10
[A;a-l	1,1, dichloroethane	4.0		•	60-0/10
[A7a-2	1,1,1, trichloroethane	4.0	66-0/10	90-0/10	70-6/10 80-0/10 90-0/1 0 100-4/10
[A7a-5	Trichloroethylene (industrial)	2.3	111-0/10	100-0/10	
[A7a-4	Carbon Tetrachloride	2.3			
IA7a-3	Chloroform	1.5			300-0/10

⁽¹⁾ ABMA type tester. 33-37 lb plummets. Douglas Aircraft Company: Compatability of Materials with Oxygen. October 1, 1958.

⁽²⁾ ABMA type tester. 40-60 lb plummets. Dow Chemical Company: (same report as (1).

⁽³⁾ ABMA type tester. 20 lb plummets. The Martin Company, Peakham, H.M. and R. L. Hauser: Compatability of Materials with LOX. Adv. Cryo, Eng. Volume 4. (1959).

DISCUSSION OF RESULTS

The order of sensitivity of 1,1, dichlorethane; 1,1,1, trichloroethane; trichloroethylene; and chloroform is the same in the LOX impact tests and in our tests (Table II).

Methylene chloride showed a highter sensitivity in our test than in the impact tests. It is not as highly chlorinated as the other solvent and, therefore, the higher sensitivity is not surprising. The difference in behavior at low temperatures only emphasizes the higher sensitivity of our test.

For carbon tetrachloride, no comparable data were found at LOX temperatures. It is more chlorinated than chloroform and its sensitivity should possibly be less than that of chloroform. It is conceivable that if twenty tests were made instead of six, the final evaluation would show a lower sensitivity than chloroform. It was noted in the results (Table I) that reproducibility becomes poorer for lower sensitivity materials.

The results of these tests compare favorably with those of the LOX impact testers. Cheaper and simpler equipment is used. A smaller number of tests is made and the sensitivity of these tests is higher.

OTHER TESTS MADE IN THIS PERIOD

- (1) "T-Film" thread compound. Sensitivity 0.0.
- (2) "Penton" gasket material. Sensitivity 5.0.
- (3) Oil from Aloquippa pump suction residue. Sensitivity 5.0 (3 failures).
- (4) "Cyl-Seal" thread compound. Sensitivity 3.0.
- (5) CS Sensitivity > 5.0 (two spontaneous ignitions).

TESTS WITH LOX

Attempts to use this method at low temperatures by condensing oxygen in the pressure bomb by cooling with liquid nitrogen failed. Hexadecane was the material used in these tests. Inspection showed that the igniter had operated but that the hexadecane had come off the walls and collected at the bottom of the bomb as a solid mass.

It is planned to repeat these tests with bombs of the same diameter, but smaller length and to place the igniter close to the bottom of the bomb. A Teflon disc on the bottom would prevent the igniter from shorting to the body. These tests will be made during January, 1962.

ORIGINAL SIGNED BY

EL:faj

149HIGH PRESSURE OXYGEN COMPATABILITY TESTS WITH SILICONE RUBBERE GANKET C. "POUND ush SAMME LABELED KTV-60 4lt jar N.P.-134372-M235 SILICONE RUBBERE COMPOUND MFB.BY. GENERAL ELECTRIC, SILICONE PRODUCTS DEPT. WATER FORD, NEW YORK Lor = 505 MEG. WARRENTY EXPIRES 8-1-62* KTV-60 is a viscous but pourable liquid (* Sample very viscous - world not your) which cures at room temperature after addition of curing catalyst to produce a recetant, plantle lough selecone rubber. Udd curry catalyst to achieve cure rate desired (see instruction foolilet for - accommended cataly it and quantity [No instruction booklet] Nix thoroughly, agoly, and allow to cure Labelon catalyst "THERMOLITE-12" NP-134376 -B 109 29 (2 ml) container Contents of jar was a rust sed alor, and cotalet was close. Is we had no formula for mixing material, we used up all the material. Plastic like sufstance was agreed on a gloss state and allowed to cure overnight. Material well tear, but does have good elasticity. Material does have a tending to after to itself but can be separated. It was not difficult to lift the material from the glass glate the following day. Triestones to ling may ve due to suction. Reaction bombs containing sample were affected to the high greasure manifel where 3 purge cycles consisting of atternate presouring atom and concentrate were correct out. Bombs then presoured to 2000 psig Oxygen, and ignition potential applied.

Nos 1, 2, 43, no apparent reaction. Contents yammood - sample anapparent Upon ignition pressure rose immediately to 3800 ps of award the fully released through the tiflon, which had mediately from the exotionic reaction gray winds No 5 (substitute manifold gauge for test pressure of 100 prig) Good ignition no apparent reaction. Examination revealed sample in contact with fuse-No. 6 @ 100 psig - Upon ignition - pressure increase to 120 psig - No indicate Examination revealed sample that was suspended on the filament were was a hard ash - masson grey in woon. Sample does react unfavorably with oxygen.

2



E. P. Thomas

W. W. Schmover

Oxygen Compressors - Your Memo of January 21, 1969

cc: J. J. Dwyer
K. D. Kohnen

W. T. Pector

In a telecon with Halocarbon Products on February 4, the following information was presented.

Halocarbon wax 6-25 is a blend of 25% 600-wax and 75% 113-Freon. This blend was made to Linde specifications for the spray coating on oxygen systems being placed in temporary storage. The recommended use is to apply the blend through appropriate spray equipment utilizing dry nitrogen or a similar inert gas as the pressure source. Upon application, the Freon will evaporate leaving a thin deposit of 600-wax on the surfaces treated. The melting point of this material is 60° C and its use in an oxygen compressor would soon cause the material to be displaced and passed down the line.

Removal of this coating from storage equipment would not be necessary if the ultimate use temperatures exceed 60°C. At some point downstream of the use temperatures, it may be sufficiently cool to recondense some of the vaporized 600-wax and may be a problem to other areas downstream.

There is no technical data available for 6-25 wax.

ORIGINAL SIGNED BY,

W. W. Schmoyer

WWS:bp

DATE: 4/11/61 LAB. NO.: 61-262

SAMPLE OF:

Fluoro-glide

FROM:

Safety Department

SAMPLING DATE:

REQUESTED BY:

F. Kitson

SAMPLED BY:

ANALYSIS REQUESTED:

Flammability in 100% gaseous oxygen

ANALYTICAL METHOD:

ANALYST: L.Y.

IWO NO.: 81-0029

PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

The dry film of fluoro-glide did not ignite when heated to 900°F in a 100% gaseous oxygen atmosphere. The solvent evaporated too rapidly to obtain a liquid sample.

cc: W. Ent

F. Kitson

E. Lambert

C. McKinley

W. Mellick

jlm

TECHNICAL MEMORANDUM

RESEARCH AND DEVELOPMENT DEPARTMENT

AIR PRODUCTS, INCORPORATED

ALLENTOWN, PA.

TM #40

INVESTIGATION OF THE FIRE RESISTANT QUALITIES OF

CELLULUBE 220

WORK DONE BY: C. J. Heatley

E. R. Dinan

REPORTED BY: W. L. Ent

DATE: September 18, 1959

INTRODUCTION:

The fire resistant qualities of Cellulube 220 as an air compressor cylinder lubricant has been investigated.

Analyses and tests performed include the comparison of Flash and Fire Points and other physical characteristics of Cellulube 220 with other synthetic and hydrocarbon lubricants; and the comparison of the relative explosible nature of the Cellulube 220 Lubricant in oxygen, air, and mixtures of oxygen and nitrogen, both in the gaseous and liquid state, with the explosible nature of other lubricants with like mixtures of oxygen or oxygen & nitrogen.

EXPERIMENTAL:

The following table lists the Flash and Fire Points of the various lubricants tested:

TABLE I

Manufacti	ırer	Trade Name	Grade		Type	Flash OF	Fire OF
Celanese	Corp.	Cellulube	220	Cresyl-Pi	-	** 510	**670
Celanese	Corp.	Cellulube	150	Cresyl-Pi Poly	hosphate ymer	**660	**700
Carbide 8	& Carbon	UCON	LB283	Glycol	Base	428	480
11	11	11	LB550	19	ŧŧ	542	590
11	11	11	LB300	11	27	518	570
11	tt	11	LB170	**	11	440	530
11	11	tf	нв170	*1	11	410	475
11	11	11	нв660	†I	tt	460	505
Hooker		Auralube	FS	Fluoria	nated	*None	*None

^{*} 800° F - no ignition.

^{**} Decomposed - ignition at indicated temperatures.

TABLE I (Cont.)

Manufacture <u>r</u>	Trade Name	Grade	Type	Flash OF	Fire OF
Hooker	Fluorolube	FS5	Fluorinated	*None	*None
M. W. Kellogg	Kel F	LF3	11	*None	*None
General Electric	Versilube	F-50	Chlorinated	525	650
General Electric		SF81(40)	Silicone	597	815
Monsanto	Pydraul	F - 9	Phosphate Ester	430	675
Dow Corning	4 Compound		Silicone	460	600
11 11	4X "		11	500	570
Fairbanks- Morse	Silicone Grease	DC-44	11	460	490
Alpha Corp.	Molykote	Microsize		*None	*None
Monsanto	Pydraul			- 650	650
Gulf	Mechanism	400 600	Hydrocarbon	320	380
Havoline	н D	gan 445	ti	490	495
Shell Oil Co.	Shell	2-1176-A	11	473	482
Indoil Chemical	Indopol	L-10	Polybutene	268	291
Indoil Chemical	Indopol	H-300	11	512	562
Mobile	DTE	105	Hydrocarbon	480	490

^{* 800°}F - no ignition

In addition to the above listed data, the following information has been determined on the Cellulube 220 Lubricant:

Appearance	Clear - viscous
Odor	Slight - (mild)
B.P. @ 10 mm	509-545 ⁰ F
Volatility (6 hrs @ 100°F)	Max1%
Auto Ignition Point	1175°F
Hydrolysis (16 hrs. @ 212°F)	Trace
Solubility in water (ml/l00ml)	.303
Surface Tension (dynes/cc @ 25°C)	1,1,
Viscosity (Saybolt Universal @ 100°F)	220 sec.
Pour Point	-5°F
Specific Gravity (gms/cc @ 20°C)	1.145

Explosion tests were performed on all of the above listed lubricants. The majority of these tests were performed in liquid oxygen with the lubricant being present in an amount so as to exceed its solubility in the oxygen. This is the standard Air Products test for explosibility in liquid oxygen and is performed by detonating a mixture of the lubricant and liquid oxygen; a blasting cap or M-2 photo flash bulb being used as an initiator. The results of this initiation yields an explosion (positive test for explosibility) or a mere rupturing of the container (negative test for explosibility). Positive tests were determined for all of the above listed lubricants with the exception of the Hooker Company's FS and FS5 and Kellogg's Kel F.

Further tests were performed on the Cellulube 220 to determine its compatibility with varying gas phase oxygen-nitrogen mixtures and to determine the auto ignition point of Cellulube in air and oxygen rich atmospheres. The results of these additional tests were as follows:

1. Four grams of Cellulube 220 were placed in tubes similar to the ones shown on the enclosed sketch and were pressurized to 1000 psig with gaseous mixtures containing 100%, 50%, and 20% oxygen. Electric matchheads which had previously been sealed within these tubes were used as initiators. Loud, brissant explosions resulted in the tubes containing the Cellulube with 100% and 50%

oxygen mixtures. Combustion, but no explosion, occurred in the tube containing the four grams of lubricant with the 20% oxygen mixture. This combustion was evidenced by the discoloration of the inside of the tube as a result of the rise in temperature.

2. Spontaneous decomposition or auto ignition tests were performed, using a heated tube technique. Here again four grams of lubricant were placed within the tube as shown in the attached sketch, and varying percentages of oxygen and nitrogen were introduced to pressures of 700, 1500, and 2000 psig. The temperature was raised within and around the tubes by placing it in a furnace. The temperatures at which combustion initiated and at which explosions occurred were recorded.

The following table lists the data recorded in these tests.

Auto-Ignition of Cellulube 220

Test No.	Mol % 0 ₂	Test Press. Psig.	Mixing Temp. OF	of Tempera	uctu ation ature Initiation	Conditions explosions Temp. OF	
1.	100	700	102	300	740	875	1140
2.	100	740	90	660	1015	1010	1015
3.	75	700	985	*	*	1230	740
4.	50	700	670	*	. #	1220	765
5.	50	740	95	650	1025	1025	990
6.	20	700	520	885	740	1195	785
7.	20	2000	105	##	**	615	2715
8.	20	735	103	815	1100	990	1130

^{*} Mixing temperature above auto ignition point

^{**} Auto ignition and explosion points identical

One additional test was conducted to simulate average compressor pressure and temperature conditions. The four grams of oil were placed in a tube, heated to 300°F and pressurized to 1500 psig. No auto ignition or explosion occurred. Subsequent visual investigation of the oil in the tube showed it to be clear with no evidence of discoloration.

The data presented here show that generally a temperature higher than 650°F was required for auto ignition. On one occasion, using 100% oxygen, a reaction was observed when a temperature of only 300°F was reached.

Explosions were not obtained until temperatures of about 1000°F - 1200°F were reached, except when the initial test pressure was 2000 psig. In the 2000 psig test the high pressure probably caused the combustion reaction to proceed rapidly to explosive conditions. The data also clearly demonstrates that mixtures of oil and gases containing oxygen are of an unpredictable nature.

CONCLUSIONS:

- 1. The Flash and fire points of Cellulube 220 are higher than normally used hydrocarbon oils.
- 2. In those cases where the flash and fire points of other synthetic lubricants are higher than Cellulube 220, these other lubricants are of a corrosive nature or cannot be considered because of their extremely high cost.
- 3. The auto ignition temperature of Cellulube 220 at maximum air compressor pressure is approximately twice that of the comparable compressor temperature in OF.

EXFLOSIBILITY & AUTO-IGNITION

TEST APFARATUS

B. W. Campbell

W. L. Ball J. H. Body

L. G. Frederick

ANALYTICAL REPORT

Air Products and Chemicals

D. F. Latshaw C. McKinley

H. W. Pattillo

DATE:

1/30/70

LAB. NO.:

70-026 LAB BOOK: 1374

SAMPLE OF: Gasket Material

FROM:

Melrath Supply and Casket Company

SAMPLING DATE:

REQUESTED BY: H.W. Pattillo

SAMPLED BY:

ANALYSIS REQUESTED: Compatibility of Melrath material with oxygen

ANALYTICAL METHOD: Combustion in oxygen and Soxhlet ether extraction PROJ. NO.:

ANALYST: L.G.F.

IWO NO .: EA-7027

REMARKS:

ANALYSIS

A sample of Melrath gasket material was submitted to this lab in order that its compatibility could be checked with oxygen. It was also requested that the Melrath material should be compared to Garlock 900 gasket material. The following three tests were performed on the Melrath material.

- 1. Ignition in an oxygen environment The Melrath material was ignited and placed in a Schöniger flask containing 100% oxygen. Combustion occurred for approximately ten seconds with only a few minor char marks on the material. Under a similar test the Garlock 900 burned for approximately twenty seconds and was considerably more charred than the Melrath material.
- Contact with LOX The l'elrath material was placed in a LOX bath for a period of five minutes, and then removed. It was then dropped on a lab bench. There appeared to be no visible damage or changes in the characteristics of the Melrath material.
- 3. Ether Extraction Samples of Melrath and Carlock gasket material were placed in separate Soxhlet Extractors and extracted for 22 hours with 250 ml. of diethyl ether. The following results were recorded for this experiment:

	Sample Wt. (grams)	Residue (grams)	Percent Ether Extractable Contaminants	Fluorescence
70-02€ Melrath	7.71832	0.22654	2.91	Negative
70-013 Garlock 900	7.94630	0.14720	1.83	Negative

250 ml. ether blank = 0.00206 grams



Page 2

DATE: 1/30/70
LAP NO.: See Page 1

LAB BOOK: 1374

SAMPLE OF: Gasket Materials

Percent ether extractable contaminants was calculated by the following formula:

$$% = \frac{\text{Extracted Residue - Blank}}{\text{Sample Wt.}} \times 100$$

Infrared spectra of the residue from the Melrath and Garlock materials shows both residues to be aliphatic hydrocarbons which are similar in structure.

Infrared spectra of the residue from the KM-226, KM-246 and Garlock 900 materials shows all the residues to be aliphatic hydrocarbons which are similar in structure.

Conclusion: Due to the ignition characteristics and the high percentage of ether extractable contaminants in all the materials, it must be concluded that none of the materials are completely compatible with oxygen. However, it does appear that the KM-226 and KM-246 are no worse than the Garlock 900.

ORIGINAL SIGNED BY

D. R. Latshaw

DATE: 1/30/70 LAB. NO.: See Below

LAB BOOK: 1374

SAMPLE OF:

Gasket Materials

FROM:

Safety Department

SAMPLING DATE:

REQUESTED BY:

SAMPLED BY:

ANALYSIS REQUESTED:

Compatibility of gasket materials with oxygen

ANALYTICAL METHOD:

Combustion in oxygen and Soxhlet ether extraction

ANALYST: L.G.F.

IWO NO.: XD-0123 PROJ. NO.:

R&D PROJ. NO.:

REMARKS:

ANALYSIS

Samples of gasket materials KM-226 and KM-246 were submitted to this lab in order to determine their compatibility with oxygen. It was also requested that these materials should be compared with garlock 900 Gasket material. The following tests were performed.

- 1. Ignition in an oxygen environment Ignition of the KM-226 and KM-246 materials in a Schöniger flask which contained 100% oxygen showed that both samples burned for approximately twenty seconds with considerable charring of the material. Under a similar test the Garlock 900 also burned for approximately twenty seconds with considerable charring of the sample.
- 2. Ether Extraction Samples of KM-226, KM-246 and Garlock 900 were placed in separate Soxhlet Extractors and extracted for 22 hours with 250 ml. of diethyl ether. The following results were recorded for this experiment.

,	Sample Wt. (grams)	Extracted Residue (grams)	Percent Ether Extractable Contaminants	Fluorescence
70-013 Garlock 900	7.94630	0.14720	1.83	Negative
70-014 КМ-226	23.31190	0.63110	2.70	Negative
70-015 KM-246	7.71409	0.24067	3.09	Negative

250 ml. ether blank = 0.00206 grams

Percent ether extractable contaminants was calculated by the following formula:

% = Extracted Residue - Blank
Sample Wt. x 100



Page 2

DATE: 1/30/70
IAB NO.: 70-026
LAB BOOK: 1374

SAMPLE OF: Gasket Material

Conclusion - Due to the ignition characteristics and the high percentage of ether extractable contaminants in the Melrath material, it must be concluded that the Melrath material is not totally compatible with oxygen. However, it does appear that it is no worse than the Garlock 900 material.

DRIGINAL SIGNED BY.

D. R. Latshaw

DRL:dag

W. L. Ent

W. H. Mellick

G. E. Schmauch

AIR PRODUCTS INC. ANLAYTICAL REPORT

Date: November 6, 1963 Lab. No.: 63-1662 & 1663

Sample of: Valve Washers (New & Used)

From: I&M Engineering

Sampling Date:

Requested By: W. L. Ent

Sampled By:

Analysis Requested: Qualitative and Quantitative Oil Analysis

Analytical Method: Soxhlet Ether Extraction

Analyst: SRM, RB IWO No Remarks: IWO is complete IWO No.: 69-1084 Proj. No.:

R&D Proj. No.:

ANALYSIS

LAB NO.	SAMPLE	OIL CONTENT, GRAMS	I.R. IDENTIFICATION
63 - 1662	New Valve Washer	0.0062	Aliphatic Hydrocarbons
63 – 1663	Washer from Blow Valve	0.0220	Aliphatic Hydrocarbons

Both extracts contained the same type hydrocarbons, since the infrared spectra were identical in each case.

Re-typed May 26, 1972 kfq

		4



PUT IT IN WRITING

DATE: September 30, 1960

G. Brandt (2)

J. N. Wentz (2)

SUBJECT: Combustible Contaminant Content

FROM: W. L. Ball - Safety Dept.

in Graphite Impregnated Asbestos Packing

cc: C. R. Anderson

L. P. Pool

W. P. Havers

P. A. Elsen

C. J. Schilling

C. McKinley/W. L. Ent

W. A. Josephsen

H. Valentine

L. Von Szessich

D. F. Baker

In the Safety Department's report, "Combustible Contaminant Content in Graphite Impregnated Asbestos Packing," dated 7 April 1960, it was recommended that a program be set up to evaluate the necessity of limiting combustible contaminants in packing to our present standard of a maximum of 0.035% by weight. It was suggested that Research & Development test packing with various known contaminant levels to determine the degree of contamination required for reaction. This work has now been completed and is summarized below.

HISTORY

TO:

As noted in the previous report, no records could be found indicating how the maximum combustible content of 0.035% by weight for packing in oxygen service was established. As the manufacturers of this packing, as well as the best cleaning procedures that Air Products could devise, have found it difficult, and on many instances impossible, to attain this level, it was decided to determine if this degree of cleanliness was actually required.

Raybestos-Manhattan was requested to review their operation to determine, if possible, the type of hydrocarbon contaminant found in the packing. Mr. Kushubar, Packing Engineer for Raybestos-ra....

Engineer for Raybestos-ra....

contaminants were being injected during a ...

asbestos at the mines. The furnace in some instances was c.

was exposed to the cumbustion products of an oil-fired burner. Other source

steam tables, which eliminate contamination at this stage. After reviewing the further processing of the asbestos, they were positive this was the only source for the contamination.

plunger siezed. The Service Department reported that heating under these conditions was sufficient to discolor the shaft, indicating a temperature in the neighborhood of 1000°F.

An attempt was made to identify the actual contaminant by analyses, but it was impossible to obtain sufficient contaminant samples for study. It was decided that a light kerosene would approximate the actual contaminants in the packing.

Research & Development was therefore requested to (a) prepare samples of the packing with various levels of contamination, and (b) test these samples for combustion in a pure oxygen atmosphere at temperatures to 1000°F. The apparatus available at R&D was able to heat the samples only to 950 to 975°F.



DISCUSSION OF TEST RESULTS

Test results are tabulated in Table 1. The following points should be noted:

- 1. Combustion occurred in teflon-coated asbestos packing at 960° to 970°F at all contaminant levels tested (from no detectable contaminant to 1.18% contaminant).
- 2. No combustion was noted in graphite impregnated packings containing 1.14% by weight of oil or less, when tested to 950°F.
- 3. Combustion in graphite impregnated asbestos packings occurred at 500°F or lower at contaminant levels of 1.30% by weight.
- 4. Teflon-coated blue asbestos lost 45 to 48% by weight in the combustion tests.
- 5. Blue African asbestos contains 25% or more iron (reference "Scott's Standard Methods for Analysis", 5th edition, Volume II).

These tests indicate that between 1.20% to 1.30% by weight of oil is required for combustion in a pure oxygen atmosphere. The combustion of the teflon-coated packing at 960°F was due, not to oil or hydrocarbon contamination, but to combustion of the teflon or the decomposition products of the teflon. This is shown by the fact that the reaction occurred at essentially the same temperature regardless of the amount of contaminant in the packing; also, by the fact that the packing lost 45% to 48% of its weight during the combustion tests.

If we take the lower value of 1.20% oil required for combustion, the present maximum permissible oil content of .035% gives a safety factor of 34.4.

RECOMMENDATIONS

Based on the above data, the following recommendations are made by the Safety Department:

- 1. The maximum allowable oil content of packing intended for oxygen service may be relaxed from 0.035% to 0.20% by weight (retaining a safety factor of 6).
- 2. Inspection and Quality Control must continue to check every shipment received from our vendors to insure that this level is not exceeded.
- 3. Because of (a) its high iron content, (b) its higher degree of abrasiveness, and (c) its higher cost (as quoted by Raybestos-Manhattan) over the white asbestos, it is suggested that the use of the blue African asbestos be re-evaluated.
- 4. As soon as the R&D Department's Kinetics Laboratory is set up, pump packings contaminated to various levels as was done for the combustion tests should be tested for reaction to impact in liquid oxygen.

W. Leonard Ball

WLB:ph

Att. - Table 1

Re-typed May 24, 1972 kfq

Attachment to W. L. Ball's memo of Sept. 30, 1960

TABLE 1

Type of P	acki:	ng	Contaminant Level (% wt.)	Maximum Temp.	Reaction	Laboratory Report Number
Graphite Impre	gnate	ed Asbestos				
Dwg. Dwg.	No.	32995A 25833A 25519A	.053 .103 .920 1.02 1.14 1.30 1.48 1.60	975 700 950 950 950 5 00* 488* 498*	Negative Negative Negative Negative Negative Positive Positive Positive	60-141 60-321 60-321 60-321 60-321 60-321
Teflon Coated Dwg.		stos (blue) 57991A "	None Detectable .054 .173 .42 1.18	960* 963* 970* 960* 960*	Positive Positive Positive Positive Positive	60-224 60-224 60-224 60-224 60-224

Re-typed May 24, 1972 kfq

^{*} Temperature at which reaction occurred.

PUT IT IN WRITING

Date: November 6, 1959

TO: See Distribution Below

SUBJECT: Quality Control of Rock Wool

FROM: F. Himmelberger

Copy to: C. R. Anderson

B. E. Moody J. L. Cost L. P. Pool P. G. Foust C. J. Schilling J. Graeffe J. N. Wentz M. H. Halsted B. F. Wobker

C. McKinley

Since the accident at ICI, Air Products (Great Eritain) has investigated methods of controlling the oil content in rock wool. In procuring wool for the Stewarts & Lloyds box, they insisted upon the addition of a red dye (Wanoline Rod, made by ICI) so that the distribution of oil in the wool could be readily observed. This was considered a satisfactory and necessary step, inasmuch as the English rock wool contained more oil in general than that which we use here and the distribution of oil in samples upon analysis appeared to be non-uniform. One ounce of dye was added per imperial gallon of oil. Average oil contents were on the order of 0.3% to 0.4% after manufacturing. Concurrently, tests were made that showed that a minimum of 4.0% oil is essential for rock wool to display any flammable properties. (There was no indication that the ICI explosion was caused by oil added to the wool in manufacturing, since all samples analyzed showed the oil content to be far below the 4% level required for flame propagation.)

As a result of the English experience, the question has arisen as to whether or not dye should be added to control oil content of rock wool purchased in the U. S. Some thoughts on this subject follow. Please bear in mind that we do not have all the answers at this time, but feel that our investigation to date has indicated that dye tracers need not be applied in rock wool of American manufacture.

The use of dye presents a number of problems. The first of these relates to quality control. Since the dye to be chosen must be soluble in oil, we must immediately become suspicious of it having a lower flash point than oil; it may thus alter the combustible properties of the oil. Some dyes are flammable or explosive in air. Aniline would react violently with oxygen. Some dyes exhibit toxic effects which could have bearing on handling problems in installation and in maintenance problems on completed plants. Since we have been worried about the behavior of oil in rock wool during warm-up and cool-down cycles, we would also have to investigate the behavior of the dye in the cold box environment. Should it become necessary to resort to adding dye to rock wool, additional cost in quality control of the wool would ensue. This would be manifested in verifying that the proper dye was selected, that it was added to the oil in the proper quantities, and that its distribution in oil and in the wool was in effect what was required. While the cost of adding dye would be insignificant, the cost of quality control people would not. Another serious objection to the use of dye is that visual inspection of the relatively clean, white rock wool after installation has always been adequate in the detection of contamination during the packing process or after installation. Some forms of contamination would be more difficult to observe in a dyed rock wool. Expander oil, for example, has a reddish tint.

However, the chief objection to the use of dye is that other approaches seem far more simple and far more effective. In the first place, American manufacturers by the use of a spinning process have been able to reduce the oil content on normal runs--not necessarily for air plant application--to 0.15% oil by weight. They can verify the uniform distribution of this oil by black light inspection. Some manufacturers use electronically-controlled automated units to govern oil addition in the manufacturing process. At least one manufacturer also claims that oil-free rock wool can be provided and that the only disadvantage might be in dusting problems during installation.

Using this information as a background, we are presently in contact with Project Engineering and the Wilkes-Barre plant to effect the necessary action to use oil-free rock wool in a future box. Should no handling problems become apparent, we see no objection to specifying oil-free rock wool on all future jobs. In the event that some suppliers cannot provide oil-free rock wool (this may occur where field packing becomes essential) or in the event that the oil-free material presents unsurmountable handling problems, we are pursuing an analysis of production techniques and quality control procedures using black light.

ORIGINAL SIGNED BY

F. Himmelberger

FH:ph



October 23, 1970

Distribution

Flammability Test of Gaskets in Oxygen

F. K. Kitson

Atmospheres

Distribution: W. L. Ball

M. R. Hillegass

A. Lapin*
C. McKinley*
W. W. Schmover*

This will confirm our discussion of this date regarding the tests that were performed at R & D on gasket materials from John Dore Company (present supplier), Melrath Gasket Company, and Valley Forge Gasket Company. These gaskets are utilized in the LOX transfer hoses. The tests, witnessed on October 21 by members of the distribution indicated by an asterisk, were conducted by wrapping a small piece of the gasket material in a small piece of filter paper igniting one end of the filter paper and then inserting the burning paper containing the gasket material into a flask containing an oxygen atmosphere. The tests established that there was no identifiable difference in the flammability characteristics between the three materials tested. Although these materials did exhibit slight charring on the extreme ends of the materials after being tested, the materials are acceptable from an oxygen compatability standpoint.

It is noted from previous correspondence that the <u>Fluorogreen E-600</u> gasket material manufactured by Dore Company is considered sufficiently compatable in liquid oxygen service as reported in NASA tests.

The tests that were performed again indicate the advisability for Air Products to develop and have ready upon reasonable notice a standard test procedure for testing materials in oxygen atmospheres.

ORIGINAL SIGNED BY

FKK:nb

PUT IT IN WRITING

Date: November 12, 1959

TO: Distribution Subject: Production of Rock Wool

FROM: E. Bassler Bethlehem Steel Company

Copy to: C. R. Anderson C. McKinley

J. L. Cost B. E. Moody P. G. Foust L. P. Fool

J. Graeffe C. J. Schilling M. H. Halsted J. N. Wentz F. Himmelberger B. F. Wobker

Reference: F. Himmelberger's memo November 6, 1959

"Quality Control of Rock Wool"

The rock wool producing facility of Bethlehem Steel Company was visited by F. Himmelberger, B. Moody, and E. Bassler on November 11, 1959. The purpose of this trip was to establish a better understanding of rock wool production and, in particular, to see how Bethlehem controls the addition of oil to the rock wool.

Rock wool is produced by melting blast furnace slag with coke and impinging a force on this liquid to produce a fibrous material. The method used by Bethlehem Steel is outlined as follows.

The molten slag from the furnace drains to the periphery of a high speed wheel. The centrifugal force applied to the slag by the wheel spreads out the slag until it reaches steam jots which are encircled around the wheel in a steam header about three inches from the edge of the wheel. The steam force pulls out the slag to form a fibrous material and also blows the wool into the blowing chamber. It is in the blowing chamter that the oil is applied to the rock wool. The oil is pumped to a jet by a positive displacement Hills-McCanna pump. As the oil leaves the jet, it is atomized by steam. The rock wool is pulled by suction to a traveling screen, which transports it to a roller, followed by a chopper. Another conveyor belt then picks up the rock wool and brings it under a chute which picks up the rock wool by suction. At this point, any heavy slag or coke particles are eliminated from the product rock wool. The rock wool is then dropped into an inclined rotating screen which because of the rolling action produces nodilated rock wool. The rock wool is then dropped into the bagging equipment.

The question of the possibility of having high oil concentrations in local areas of the rock wool was answered by observing the operation. The quantity of oil addition is the first point where control is established. For Air Products' rock wool, the oil rate is maintained at about 3.5 pounds of oil per ton of rock wool. This is the feed rate, and because of the loss of vapors due to the suction in the blowing chamber, the actual oil content of the rock wool product will be less. The atomization of the oil and the fact that the rock wool is being blown around in the chamber eliminates the possibility of localized concentrations of oil. Another feature of their automatic control is that the oil flow is stopped when the slag flow is discontinued. Therefore, any rock wool in the chamber will not receive excessive oil content.

APCI DOCUMENT NO 99000147

To demonstrate the dusting problem which would exist with oil-free rock wool, the oil addition was discontinued and almost immediately the area of the choppers and suction chute was full of dust. There was full agreement that completely oil-free rock wool would not be practical because of the dusting problems that would be encountered during installation.

Another point of information that was brought to our attention was that some rock wool manufacturers add the trimmed material from board insulation to the rock wool. This material has a high resin content and for our purposes should not be included in the rock wool.

As a result of this trip, the following action is intended.

- 1. Determination of actual oil content as opposed to feed rate oil content.
- 2. On future orders the oil content will be reduced to the minimum value which will not present handling problems.
- 3. Establishment of quality control procedures for inspecting rock wool.
- 4. The rock wool specification should be revised stating that there should be no addition of trim from board insulation to the rock wool.

ORIGINAL SIGNED BY

E. Bassler Safety Department

EE:ph

PIPE BURNING TESTS. Report submitted 17 april 61 TEST PIPE We wished to experiment on a situation that could or possibly would No. SIZE happen in plant giping If someone was using a burning touch INCHES near an oxygen line, and accidently lurned the type through what 1/2 migh as 300 + psfg. * assuming that pressures would run only as high as 300 + psig. 3. 1/2 1/2 4. To approach these conditions we assembled a oxygen affinder, equiped with a high pressure regulator attached to an accurate 1/2 gage (Here 0-500 psig) with which we could obtain DP in cylinder to calculate flows. Valred of from the rest of the system was set up STAL a line directly connected to sign of various NPS as 4-2-1. who per and. Pipe was to be heated at the outlet and with various flourings Or through the pipe, until it began to burn. Tinear travel of burning Z 9. was to measured both in inches & time elapsed during burning 11. In origaning sipes for test, they were cut to length (24") threaded 12. ap we progressed with tests, we found it necessary to engther 13 14. the Eline from the regulator to the sipe sample, as the "J.T. of of our balve was sub- cooling the oxygen flowing through orge 15. 16. for the furning last. at this time, the safety department (API) wished to know whether 17. or not a water hose could be used afficiently as a means of fire extinguishing. During our sums we encountered only onlinitary 14 of continual burning where this technique could be tested. mose stopped the burning in Oseconde or slightly less, by cooling 1/4 22. 14 the metal enough to stop combustion. 23. at a later date several other tests were also run & added to the 24. 25. bollowing table. The data collected in graph form shows a difficult spattering of results, however, it was felt that the burning rate 26. sige increases with Or flow and decreases in page chamite size. 27. 28 In the second set of experiments, 2 flow moters 29. 12 to measure Or flow, as the first group of tests indicated 30. 2 31. 1/2 sight winch to be devised now manyout because of the to dynamic log. 32. 1/2 . 33. , 1/2 34. 35. 1/2 36. 1/2

> АРСІ DOCUMEN 10. 990001≪4

	-	2.0	1-	Oz 1	FLOW	TIME	Frow	RATE	- & Bur		ا الله الله الله الله الله الله الله ال
TEST			Oz		FINAL	INTERVAL	, ,	LENGTH BURNED	TIME	BURNING	REMARKS
No.			PRESS.	THITIAL PIECES.	PRESS.	S ECONOS	CFM	INCHES	SECONOS	1 4470	
	-	NCNES V				23	5				In first four tests are morbed
1 /		/2	150			1				I	pipe and we waited until barn
2.	i	1/2	50			5	12				programment marked spot. Set
3.	1	1/2	100		·	20	12		1)
4		1/2	50						1 / .	1	Pipe and luring lefre O. flow of Come that of O. flow opposite with the process of the pipe care U. J. Effect
5.	İ	1/2	50	ļ ——		18	5	- To 1	1		Went out immediately - Porce
6.		12	35	-	-	<u> </u>		-		17-6-	- Form Value
In	US	TAL	450	A 10	! # "cu	a. LINE	To WAR	WOP GA	SAFTER	J.I. EFF	ZET FROM VALVE
(2	1	巨	35	:	·	<u> </u>					
8	T	Ł	40	1845	1832	38	2.08		2		
9.		左	100	1832	1775	. 60	5.7				
10.		1/4	20		1783	67	.9	4.75	38	.625	
11.		14	40	1783		26	1.85			<u> </u>	Extraguel lifere seaching start
12.		1/4	40	1775	1758	44	2.32		1		
13.	- 1	1/4	10	1758		39	2.0		1 /	ļ ——	<u> </u>
			7	7		25	5.52		2	<u> </u>	1
14	- ī	14.	100			65	1.48	6.0	36	,833	
15	į	1/	30		1709	•	1.64	. +		Ī —	
16.	- î	14	35		•		.97	T .	20	.5	
17		14	25			14	.86	1	1	:	
18		14	, 23	1600	1683	1/	.00	رب برا	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1		Us motiveable change in re
- 19.		Ron			-only w	heated.	Karger o	una con	95	.63	No extrest change in real Burning quenched by H. O in 10.
20.	1	14	35	1677	1650	95	1.7	12	1		Estinguished before reaching test is
21.		1/4	150	-	1 -		- "	1			Program was soll extura
22		14	35	FTrus	to dup	licate l	farning	as in los	u- "uns	ncteospas	Burning was self exting
23	5	14	35	7)		4	1				
24		1/4	35	1	1540	81	2.2				
- \25	-	1/4	35	1538		Γ.	1.1			1015	-
26		1/2	35	1525		1	1.58	.5	53	.475	
27		1/2	145			42	9.0		8	+ //	
26		1	160	1462	1440		2.93	1.0	30		
29		1/2	75	Ť			4.66		15		
1 30		1/2	80	1425	*		4.0	1.75	15	.58	
. 31		1/2	20	1395	t	T	3.96	3.5	23	.76	
32		1/2	100	1368	1326	48	5.25	2.5	17	1.03	
. 1		1/2	100		1305	ī	4.54	. 1	6	1.25	
. (33			90	7	Ţ	37	4.38	1.5	10	.75	
39		1/2		T	T		5.12	1 —	Ī— `	Ī	
174		1/2	80	1280			4.18	1.25	الح	2.08	, T
30	_	1/2	85	1253	1230	, <i>OO</i>	1.10	1,20	ι .		
34	•	7		•	•	*	•				
· · · · · · · · · · · · · · · · · · ·	•							<u></u>			M. Broket 1734

			OFFLOW TIME FLOW RATE & BURNING				NING		Tar P			
T	PIPE.	Oz Press.	INITIAL PRESS	FINAL PRESS	TNTERVAL	FLOW !	LENGTH BURNATO	TIME	AVERAGE BURNAR PATE	REMARKS	.TEST . No.	Co
•	INCHES	.,,,,,,	9319	PEIG	SECONDS		INCHES	Seconos	FT. MIN.			
7	1/2	80	1255	1170	85	5.36	3.75	13	1.44	Trud more initial hasting on pipe.	1.	DE
8	1/2	90	1170	1150	3/	387	2.75	10	1.38		i	77
7	1/2	70	1150	1130	40	3.0	2.0	10	1.0	Heated only I got on pige	2.	
į	1/2	74	1134	1118	40	2.4	2.5	10	1.25	Point-healing	3.	1 - 4
/	1/2	74	1118	1100	34	1.41	.75	10	*5	- A.B.R. Reading doubted.	4.	
,	1/2	74	1100	1079	49	2.59	1.5	10	.75		٠ ٥ .	1
	No	1	•	TION I	,	FOR	TESTING					GA
,	1/2	74	PE SEC	1075	30		-			INTIME PRESSURE NOT ROLARDED	6.	16
, /	1/2	74	1078	1057	39	3.23	1.25	14	.46			11
_	1/2	80	1058	1043	27	3.33	,75	8	.47	Borning ceared, then schindled	. 7	
_	七七	90	1045	1023	29	155	1.75	11:	.80		8.	OL
	1/2	90	1025	1009		7.00	1.0	8	.61			Pi
,	f .	85	1010	995	26	3.46	1.5	8	.97		9.	1
,	1/2 /2	85	995	983	23	3.13	1.5	6	1.25	Started heating w/ No b top rather than " 3 as in other tasts.	10.	1
		ŧ	,	†	40	6.3	2,5	20	.625		.11.	
	/2	120	985	943	28	536	1.5	8	.983		12.	
	1/2	120)	•	25	432	1.25	7	.89		•	
?	1/2	120	225	907	23	6.5	1.5	6	1.25		13.	G
,	1/2	150	907	882	35	6.34	125	2	.89		,,	7
: -	1/2	150	883	846		9.81	250	12	1.04	Burne more fiercouly extinguished	,	Us
_	1/2	200	854	800	33	7.5	2.10	17	1.75	Jungan	•	BI
	1/2	200	800	775	20	•	1.0	5-	10		14.	.0.
7	1	250	795	750	23	11.74	.5	1	.623	The special residence of the contract of the c	·- • • •	No
•	12	250	750	720	· •		+	12	.3/	1	15.	2
7	1/2	150	720	695	28	6.2	.75	12	.835		,,,,	3
		150	700	670	29	+	1.0		.000	The same of the sa	16.	10
	/	100	668	643	34	9.50	10	5-	1.0	Both a Marine Count	12.	
	/	200	646	608	24	1	1		1.0	Bottom Rolf of orger burned	, , , ,	
3	/	250		570	23	1043	20	16	625			
"	1 /	300	575	503	37	11.69		2	† · · · _		. •- •-	
_	/	300	505	463	24	10.5	1.0	√ .~~	2,5			
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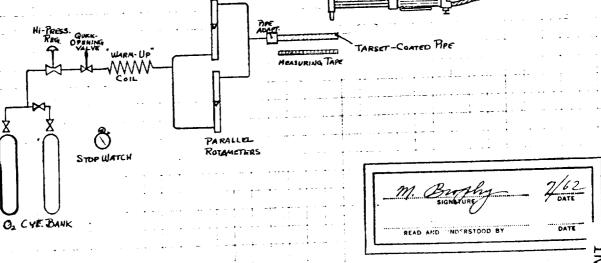
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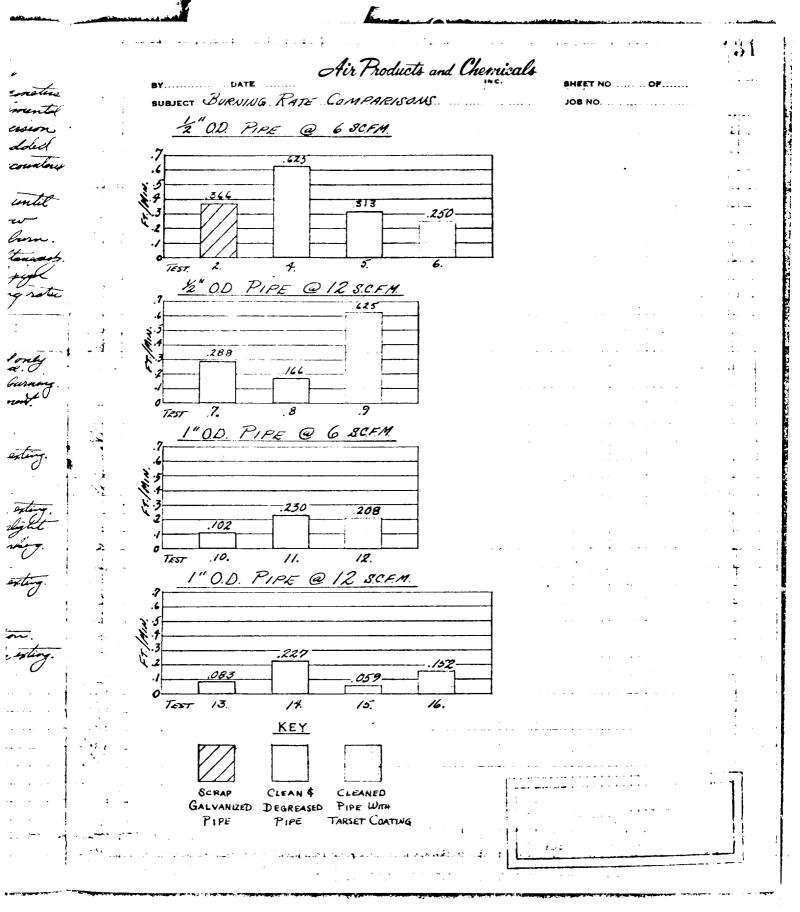


APCI DOCUMEI 10<u>92000/4</u>9 (CONTINUED FROM PREVIOUS PASE) TARSET CONTED FIPE BURNING TESTS

METHOD- The is perimental agreement was set up as per diswing on page 129 of this notation. It was necessary to consect the flowership in parallel to handle the flower encountered. Prior to the appearment runs, rotameter curves were graphically illustrated to include convision to oxygen flow, and pressure variations. It wasm-up coil was added to the agreement to combat any joules thompson effect as was encounted in the previous pipe burning experiments.

The inlet pressure was adjusted, with the togle-valve open, until we so obtained the desired flower before each test Crygen flow was then cut off until the pipe was heated sufficiently to begin to be the this time the toggle-valve was greated, and the times engaged simultaneous doubted grown from the toggle-valve was opened, and the times engaged simultaneous doubted were recorded, and calculations made for the various burning re-

								25 002.620
7	PIPE SAMPLE	THITIAL LETH.	BURNING TIME	LIGITH AFTER	CONSUMED LIGTH	FLOW	BURNING	REMARKS
No.		THENES	MIN. / SEC.	INCHES	TUCKES	SCFM	FT/MIN	!
. /.	5'0D SCRAP	19	0/8	19	:	. 6		Self estinguished Burnedonly
2.	•	19	0/41	16	3.0	6	.366	Or supply cut off to stop burning
3.	\$"OD. CLEAN	1734	0/7	1774	i ———	6		Durned only partial segment
4.	• •	1734	. 0/8	1634	. 1.0	6	.625	Self-extinguishing.
5.		1634	0/28	15	1.75	6	.3/3	Self-extinguishing.
6.	15 "OD WYTARSET	17%	1/30	13	4.5	6	.250	. Oz Supply romoved of CO2 exting.
7.	12 00. CLOW		0/13	17	75	12	.288	Self- Alinguisty
8.	"	17	. 0/15	162	.5	12	.166	Self-extingualy.
	12 OD W/TARSET	-		14	3.75	12	.625	Oz Luggly removed + CO2 exting.
10.	100 CLEW	, 22	. 0/49	2/	1.0	6	.102	Or Supply cot of bloomer of way sight
				_				· activity - only slight grandy
11.	1'QD W/ TARSET	2/1/4	0/38	20	1.75	6	.230	Solf-extinguished.
12		, zo	0/48	18	2.0	6	.208	. Or Luggly removed + CO2 exting.
13.	1 OD. CLEAN		0/30	16	-5	12	.083	Self extinguishing.
14.		16	0/33	14/2	1.5	12		Self extinguishing.
	10D. WITARSET		0/42	195	.5	12	.059	Self exting. Pour initiation.
16.		195	1/56	16	3.5	12	.152	Oz Lyggly removed + COz extins.
:								
	North Mo	vina F	CTURES 9	£ 35 mm	1 SHOTS 1	weer.	MADE OF	THE ABOVE TESTS.
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'							••.	l ,
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		····					1	
		n Bu	yly .	7/62				
		Anthe				•		
	RE	AD AND - NO	ERS1000 8Y	DATE				
	L				1			



Coma TARSET COATING (CONTINUED) SUMMARY OF TEST RESULTS While checking the graphic illustrations on gage 13/ of this motitooks, it will be noted that in every test in 19 100 @ 125CFM, the sarning rates of the tarset-cooled gipes were lesser than those of the clean river Ta tosa ids in U the clean sysew. volum Some observations were made that are not evident in the data TOI Man. pictures. There are as follows: The tasset-coated piges were a lot more difficult to initiate in the burning groces. Pictures were taken of the piges ignited and burning and therefore do not show this ghave of the experimental and burning and therefore do not show this ghave of the experimental. Threas to es ana While the clean pupes were easy to initiate, there were self-Tabe What the tarset-coated organs were finally initiated, they appeared to contain the heat, thereby purenting radiation loss, prolinging the burning, In all but one case, the Or supply had to be removed, and flames put-out with a CO. for extinguisher Sen The fire-retarded qualities of this material described the standards obtained in the placete tests, but the material definitely is one method of lowering the possibilities of page ignition lince burning, the material contributes to the continued burning of the page. Fus sa l/oc It was offered as an economical substitute for the placete but several facilio must be further explored to fully estimate to economical feature. Surface preparation is more envolved with this material Sand blasting is secommended but wire-brushing may be substituted. Being very thick in consistency (like mastic applying material is somewhat if a problem. Pressure got, barrel pump, or airless somewhat if a problem. Pressure got, barrel pump, or airless somewhat if a problem. 100 -ba application. Equipment availability is a factor to consider. of the application process to hallest for 10 to 15 minutes. I equipment clean up is necessary, with "Pett Chem Tarmastic Thinner. Two coatings are required Daying time raries up to I weeks. "Fox life is of short duration, and both components are harmful through the skin absorption and flammable. All factors to be considered against ni the At into voli € € But the state of the second of the second J. By



PUT IT IN WRITING

Air Prod	lucts, Inc.	DATE June 9, 1960	
TO	L. Ball	SUBJECT Plasite Protective	
FROM	M. Brophy	Coating	

SUMMARY

Plasite (Trade Mark Reg.) No. 7122H - Cold Set Coating manufactured by the Wisconsin Protective Coating Company of Green Bay, Wisconsin was tested in our laboratory as a suitable pipe coating for under ground lines.

All tests seem to indicate that this product exceded our expectations and it is recommended for service.

PROCEDURE

Plasite is a two ingredient mixture, with the catalyst added just prior to usage. Upon mixing the ingredients, the coating has a storage life of approximately two days. Color of test coating was green.

The spray-coating in our control tests left something to be desired, as the only sprayer at our disposal was a vibrator type that malfunctioned quite frequently. The resultant finish coat was uneven with some portions bare, while the build-up on other sections was quite heavy. Proper coating should be a film 0.015" thick. If heavier coatings are necessary they should be built-up of single 0.015" films with one hour waiting time between coats.

Samples of wood, hard board, plywood and steel pipe were sprayed as directed, and also sprayed with a mixture thinned with Plasite No. 71 thinner. Samples were air dried for seven days prior to testing.

TEST RESULTS

Two samples of steel tubing, one regular, and one thinned-coating were suspended in a 30% HOL solution for three weeks.

After one week the coatings appeared to be uneffected. By the end of the second week unsprayed areas were rusted, but coated area remained tough and hard, and very resistant to scratching.

By the third week, we were able to scrape the film from the tube, but the steel pipe beneath the coating was in good condition.

Air Products, Inc.

-2-

June 9, 1960

If the spray coating had been even, the acid solution could not have attacked the pipe as easily as there would be no exposed surfaces for it to work on. Note - Surface of pipe was not sandblasted as recommended. This would help bond the coating to the piping.

In the burning tests on plywood, wood, and hardboard the coating was burned in an oxygen atmosphere. Upon removal of flame source, the flames ceased leaving a blackened surface. The black could be wiped away revealing a dull green undersurface. This paint could be classed as highly flame resistant.

On the surfaces of the pipe, the paint had a very smooth, tough surface that resisted scratching, and did not chip when two sections of pipe were hit together. Under violent banging the paint did chip as could be expected. With proper surface preparation this test should be more conclusive.

The thin""forrest green" coating on the pipe did not flame in an oxygen atmosphere even when the temperature of the torch flame had been increased to a point where the metal pipe had melted through. The heated areas were wiped with a cloth revealing a dull green surface still protecting the pipe.

Samples were removed from the mix can and dried in an oven for several days. This mixture did burn in an oxygen atmosphere, however, where mix had been applied to the pipe as directed, there was no flame.

Original Signed By
M. Brophy

MB: jlo

Re-typed May 24, 1972 kfq

PRESSURE RATING TABLES - PLAIN AND THREADED ENDS - RED BRASS PIPE

1. PURPOSE

This standard provides the Maximum Allowable Pressures for red brass pipe with plain and threaded ends.

2. SCOPE

This standard encompasses red brass pipe made according to ASTM specification B43.

3. MATERIAL SPECIFICATION

The following material specification applies to the pipe described herein:

A. MATERIAL DESCRIPTION

IPS SIZE RANGE

(1) PIPE SMES BRS ASTM B43

1/8" thru 6"

4. ALLOWABLE STRESS VALUE

The allowable stress values for the materials described in this standard are based on ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Table 302.3.1A. The allowable stress values are based on red brass pipe at 100°F and 150°F.

A. MATERIAL DESCRIPTION

ALLOWABLE STRESS VALUE

(1) PIPE SMLS BRS ASTM B43

8,000 PSI

5. MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the pipe is based on the following formula from ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Para. 304.1.2.

A. Formula:

$$P = \frac{2S (t_m-C)}{D-0.8 (t_m-C)}$$

P = Maximum Allowable Pressure, PSI

S = Maximum Allowable Hoop Stress from 4A

D = 0.D. of pipe as listed in standard pipe specification

t_m = Minimum Wall thickness as specified by above code

C = 0.0 for plain end pipe

C = Depth of thread or 0.05, whichever is greater.

)

All information hereon is the confidential property of Air Products and Chemicals, Inc., unless another source is shown, is subject to return on demand and must not be disclosed or reproduced without prior written consent.

Date

May, 1962

	PRESSU	RE RATING	TABLES	- PLAIN EN	DS - RED	BRASS PIPE	
WEIGHT OR SCH.	nom. Size	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX PSI	lbo Per Fr.	MATERIAL CODE NUMBER
Std XH	1/8"	.405	.062	.0589 .095	2590 4620	•253 •363	1-590-05-0001 1-590-05-0014
Std.	1/4"	. 540	.082	.0779 .1168	11.81 5609	.447 .611	1-590-05-0002 1-590-05-0015
Std.	3/8"	.£75	.090 .127	.0855	2255 3334	.627 .829	1-590-05-0003 1-590-05-0016
Std. XH XXH	1/2"	.840	.107 .149 .294	.1016 .1415 .2793	2142 3114 7248	.93 ⁴ 1.23 1.91	1-590-05-0004 1-590-05-0017 1-590-05-0027
Std. XH XXH	3/4"	1.050	.114 .157 .308	.1083 .1491 .2926	1798 2562 5738	1.27 1.67 2.72	1-590-05-0005 1-590-05-0018 1-590-05-0028
Std. XH XXH	1"	1.315	.126 .182 .358	.1197 .1729 .3 ¹ 01	1570 2350 5218	1.78 2.46 4.08	1-590-05-0006 1-590-05-0019 1-590-05-0029
Std. XH XXH	1 1/4"	1.660	.146 .194 .382	.1387 .1843 .3629	1432 1949 4239	2.63 3.39 5.82	1-590-05-0007 1-590-05-0020 1-590-05-0030
Std. XH XXH	1 1/2"	1.900	.150 .203 .400	.1425 .1928 .380	1276 1766 3810	3.13 4.10 7.15	1-590-05-0008 1-590-05-0021 1-590-05-0031
Std. XH XXH	2"	2.375	.156 .221 .436	.1482 .2099 .4142	10 5 0 1522 3243	4.12 5.67 10.1	1-590-05-0009 1-590-05-0022 1-590-05-0032
Std. XH XXH	2 1/2"	2.875	.187 .280 .552	.1776 .266 .5244	1039 1598 3417	5.99 8.56 15.3	1-590-05-0010 1-590-05-0023 1-590-05-0033
Sta. XII XXII	3"	3.500	.219 .30 ¹ 4 .600	.208 .2898 .570	51.2) 1):j: 90#	8.56 13.60 20.7	1-590-05-0011 1-590-05-0024 1-590-05-0034

							Page
	PRE	SSURE RATING	; TABLES	- PLAIN	ENDS - RED	BRASS PIPE	
WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. XH XXH	4"	4.50	.250 .341 .674	•2375 •3239 •6403	882 1222 2569	12.70 16.90 30.7	1-590-05-0012 1-590-05-0025 1-590-05-0035
Std. XH XXH	6"	6.625	.250 .437 .864	.2375 .4151 .8208	590 1055 2200	19.00 32.20 59.3	1-590-05-0013 1-590-05-0026 1-590-05-0036

	PRESSU	RE RATING	TABLES -	- THREADED	ENDS - RI	ED BRASS PI	PE
Weight Or Sch.	nom. Size	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. XII	1/8"	.405	.062 .100	.0589 .095	358 1951	•253 •363	1-590-05-0001 1-590-05-0014
Std. XH	1/4"	• 540	.082	.0779 .1168	862 2197	.447 .611	1-590-05-0002 1-590-05-0015
Std. XH	3/8"	.675	.090 .127	.0855 .1206	878 1826	.627 .829	1-590-05-0003 1-590-05-0016
Std. XH XXH	1/2"	.840	.107 .149 .294	.1016 .1415 .2793	884 1718 5367	.93 ⁴ 1.23 1.91	1-590-05-000 ¹ 1-590-05-0017 1-590-05-0027
Std. XH XXH	3/4"	1.050	.114 .157 .308	.1083 .1491 .2926	811 1507 4372	1.27 1.67 2.72	1-590-05-000 1-590-05-001 1-590-05-002
Std. XH XXH	1"	1.315	.126 .182 .358	.1197 .1729 .3401	629 1342 3940	1.78 2.46 4.08	1-590-05-0006 1-590-05-0019 1-590-05-0029
Std. XH XXH	1 1/4"	1.660	.146 .194 .382	.1387 .1843 .3629	690 1170 3293	2.63 3.39 5.82	1-590-05-000 1-590-05-002 1-590-05-003
Std. XH XXH	1 1/2"	1.900	.150 .203 .400	.1425 .1928 .380	634 1094 3007	3.13 4.10 7.15	1-590-05-000 1-590-05-002 1-590-05-003
Std. XH XXH	2"	2.375	.156 .221 .436	.1482 .2099 .4142	544 992 2626	4.12 5.67 10.1	1-590-05-000 1-590-05-002 1-590-05-003
Std. XH XXH	2 1/2"	2.875	.187 .280 .552	•1776 •266 •5244	442 969 2678	5.99 8.66 15.3	1-590-05-001 1-590-05-002 1-590-05-003
Std. XH XXH	3"	3.500	.219 .304 .600	.208 .2888 .570	506 902 2407	8.56 11.60 20.7	1-590-05-001 1-590-05-002 1-590-05-003

1								rage	っ
		PRESSURE	RATING	TABLES .	- THREADED	ENDS - RE	D BRASS PIPE		
	WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER	
	Std. XH XXH	4"	4.50	.250 .341 .674	.2375 .3239 .6403	500 829 2125	12.70 16.90 30.7	1-590-05-0012 1-590-05-0025 1-590-05-0035	
	Std. XH XXH	6"	6.625	.250 .437 .864	.2375 .4151 .8208	337 791 1906	19.00 32.20 59.3	1-590-05-0013 1-590-05-0026 1-590-05-0036	



REACTIVITY OF METALS WITH LIQUID AND GASEOUS OXYGEN

Jackson, J. D., W. K. Boyd and P. D. Miller

-- \$0.75 -- AD -- 297-124

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COLUMBUS 1, OHIO

(This page re-typed 6/2/72, kfq)

IGNITION OF METALS IN OXYGEN

by

E. L. White and J. J. Ward

to

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

DEFENSE METALS INFORMATION CENTER
Battelle Memorial Institute
Columbus, Ohio 43201



Aerojet-General Corporation, "Ignition Characteristics of Metals and Alloys", L. E. Dean and W. R. Thompson, ARS Journal, p. 917-23, 7 pages, dated July 1961.

PRESSURE RATING TABLES - PLAIN AND THREADED ENDS - ALUMINUM PIPE

1. PURPOSE

This standard provides the maximum allowable pressures for aluminum pipe with plain ends and threaded ends.

2. SCOPE

This standard encompasses aluminum pipe made according to ASTM specifications B241-6061 and B209-6061.

3. MATERIAL SPECIFICATIONS

The following material specifications apply to the pipe described herein.

MATERIAL DESCRIPTION

IPS SIZE RANGE

(1) PIPE SMLS AL B241-6061-T6

1/8" thru 12"

(2) PIPE BTWLD AL B209-6061-T6

14" thru 24"

4. ALLOWABLE STRESS VALUES

The allowable stress values for the materials described in this standard are based on the ASA B31.3 - American Standard Code for Pressure Piping, Petroleum Refinery Piping, Table 302.3.1A. The allowable stress values are based on the aluminum pipe in the "welded temper", due to the fact, the material is or will be welded and becomes annealed.

MATERIAL DESCRIPTION

ALLOWABLE STRESS VALUE

(1) PIPE SMLS AL B241-6061-T6

6000 PSI

(2) PIPE BTWLD AL B209-6061-T6 & APCI 571.1.6 5400 PSI (6000 psi x 0.90 = 5400 psi)

5. MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the pipe is based on the following formula from ASA B31.3 - American Standard Code for Pressure Piping, Petroleum Refinery Piping, Paragraph 304.1.2.

Formula:

$$P = \frac{2S (t_m-C)}{D-0.8 (t_m-C)}$$

- P = Maximum allowable pressure PSI
- S = Maximum allowable hoop stress
- D = 0.D. of pipe as listed in standard pipe specifications
- t_m = Minimum wall thickness as specified in above code
- C = 0.0 for plain end pipe
- C = Depth of thread or 0.05, whichever is greater

	PRE	SSURE RATING	TABLES	- SEAMLES	SS, PLAIN	ENDS -	ALUMINUM	PIPE
6. PRE	SSURE	RATING TABLE	<u>ES</u>					
WEIGH'	T	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. (XH (40) 80)	1/8"	.405	.068 .095	.0595 .0831	1998 2947	.085 .109	1-563-01-0001 1-563-01-0026
Std. (XH ((40) (80)	1/4"	.540	.088 .119	.0770 .1041	1931 2736	.147 .185	1-563-01-0002 1-563-01-0027
Std. (XH ((40) (80)	3/8"	.675	.091 .126	.0796 .1102	1563 2255	.196 .256	1-563-01-0003 1-563-01-0028
Std. (XH ((40) (80)	1/2"	.840	.109 .147	.09 53 .1286	1499 2094	.293 .376	1-563-01-0004 1-563-01-0029
Std. (XH ((40) (80)	3/4"	1.05	.113 .154	.0988 .1347	1222 1716	.391 .510	1-563-01-0005 1-563-01-0030
Std. (XH	(40) (80)	1"	1.315	.133 .179	.1163 .1566	1143 1580	.581 .751	1-563-01-0006 1-563-01-0031
Std. ((40) (80)	1 1/2"	1.900	.145	.1268	847 1192	.940 1.256	1-563-01-0008 1-563-01-0033
Std. XH	(40) (80)	2"	2.375	.154 .218	.1347 .1907	713 1030	1.264 1.737	1-563-01-0009 1-563-01-0034
Std. XH	(40) (80)	2 1/2"	2.875	.203 .276	.1776 .2415	780 1081	2.004 2.650	1-563-01-0010 1-563-01-0035
Std. XH		3"	3.50	.216 .300	.189 .2625	677 958	2.621 3.547	1-563-01-0011 1-563-01-0036
Std. XH	(40) (80)	4"	4.50	.237 .337	.2073 .2948	574 830	3.733 5.183	1-563-01-0013 1-563-01-0038
Std. XH	(40) (80)	6"	6,625	.280 .432	.245 .378	450 710	6.564 9.884	
Std. X H	(40) (80)	8"	8.625	.322 .500	.2817 .4375	400 630	9.878 15.01	1-563-01-0016 1-563-01-0041
Std. XH	(40) (80)	10"	10.750	.365 .593	.3193 .5188	360 600	14.00 22.25	1-563-01-0017 1-563-01-0042
Std. Sch. Sch.	(40) (80)	12"	12.750	.375 .406 .687	.3281 .3552 .6011	310 340 580	15.40 18.52 30.62	1-563-01-0019 1-563-01-0018 1-563-01-0043

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Date

Oct. 1965

PRESSURE RATING TABLES - BUTTWELDED, PLAIN ENDS - ALUMINUM PIPE

7. PRESSURE RATING TABLES

WEIGHT SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
	14"	14.000	.250 .375 .500	.237 .356 .475	171 258 346	12.70 18.87 24.94	1-570-01-0001 1-570-01-0002 1-570-01-0004
	16"	16.000	.250 .375 .500	.237 .356 .475	149 225 307	14.55 21.65 28.64	1-570-01-0005 1-570-01-0006 1-570-01-0008
	18"	18.000	.250 .375 .500	.235 .355 .475	132 216 268	16.40 24.41 32.33	1-570-01-0009 1-570-01-0010 1-570-01-0011
	20"	20.000	.250 .375 .500	.232 .355 .475	126 194 240	18.24 27.18 36.02	1-570-01-0012 1-570-01-0013 1-570-01-0014
	24"	24.000	.250 .375 .500	.230 .352 .470	108 149 200	21.93 32.73 43.41	1-570-01-0015 1-570-01-0016 1-570-01-0017

	PRES	SURE RATING	TABLES - S	EAMLESS,	THREADED END	S - ALUMINU	JM PIPE
8. <u>P</u> I	RESSURE	RATING TABLE	<u>s</u>				
WEIC SCH.		NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t _m)	MAX. PSI	MATERIAL CODE NUMBER
Std. XH	(40) (80)	1/8"	.405	.068 .095	.0595 .0831	287 1050	1-563-01-0001 1-563-01-0026
Std. X H	(40) (80)	1/4"	.540	.088 .119	.077 .104	625 1307	1-563-01-0002 1-563-01-0027
Std. X H	(40) (80)	3/8"	.675	.091 .126	.0796 .1102	546 1153	1-563-01-0003 1-563-01-0028
Std. X H	(40) (80)	1/2"	.840	.109 .147	.0953 .1286	566 1096	1-563-01-0004 1-563-01-0029
Std. XH	(40) (80)	3/4"	1.05	.113 .154	.0988 .1347	492 94 3	1-563-01-0005 1-563-01-0030
Std. X H	(40) (80)	1"	1.315	.133 .179	.1163 .1566	439 838	1-563-01-0006 1-563-01-0031
S td. X H	(40) (80)	1 1/2"	1.900	.145 .200	.1268 .175	370 697	1-563-01-0008 1-563-01-0033
Std. XH	(40) (80)	2"	2.375	.154 .218	.1347 .1907	334 638	1-563-01-0009 1-563-01-0034

NOTE: 1. Valves with a designator prefix of EBV- are Extended Bonnet Valves.
These valves are to be selected from Air Products and Chemicals, Inc.
Design Engineering Standards Section 579.4

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Date

Nov., 1967

	570 PIPING	AA 1.5	Page
COLD BOX SERVICE	+100°F AND BELOW 150 PSIG M	IAX OWG ALI	UMINUM
ITEM	DESCRIPTION	SPECIFICAT	CION
PIPE			
1/4"	XH Seamless, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM B241 6061-	-T6
1/2" thru 1 1/2"	Std. Wt. Seamless, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM B241 6061-	-т6
10" and smaller	Std. Wt. Seamless, Plain Ends	ASTM B241 6061-	-т6
12"	0.375" Wall, Seamless, Plain Ends	ASTM B241 6061-	-т6
14" thru 24"	0.250" Wall, Formed from Plate, Buttwelded	ASTM B209 5083- APCI 571.1.6	-O
FITTINGS (See Note 5)			
2" and smaller	Sch. 40 Forged, Socket Weld Ends	ASTM B247 6061-	Т6
2 1/2" thru 10"	Std. Wt. Wrought, Buttweld Ends	ASTM B361 WP606 ASA B16.9	1-T6
12"	.375" Wall, Wrought, Buttweld Ends	ASTM B361 WP606 ASA B16.9	1 - T6
14" thru 24"	0.250" Wall, Formed from Plate, Buttweld Ends, (90° Ells shall be 3-piece miter; 45° Ells shall be single miter) (Tees shall be branch-welded, and reinforced where required) (Reducers shall be rolled from plate) (Caps shall be made of flat plates or spun heads; Calculations will determine appro- priate choice)	ASTM B209 5083-0 APCI 571.1.6 APCI 579.1	0
FLANGES			
2" thru 12"	150# Forged Aluminum, Weld Neck, Flat Face, Bore for Sch. of Pipe	ASTM B247 6061-T	T6
2" thru 24"	150# Forged Aluminum, Weld Neck, Raised Face, Bore for Sch. of Pipe	ASTM B247 6061-T	76

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Date

Nov., 1967

DESIGN ENGINEERING STANDARDS

571.3 Page 2 AA 1.5

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COLD BOX SERVICE	+100°F AND BELOW	50 PSIG MAX	COWG ALUMINUM
ITEM	<u>DESCRIPTION</u>		SPECIFICATION
BOLTING			
DOLLING			
All Sizes	Studs, Aluminum, Full Thd.		ASTM B211 2024 T4
	Nuts, Hex, STSTL, Tp 321 (Alternate, STSTL, Tp 316)		ASTM A194 Sym 8T APCI 579.2.2
O A O ARDINO	, , , , , , , , , , , , , , , , , , ,		,,,,
<u>GASKETS</u>			
2" thru 12"	Full Face, Compressed Asbes 1/16" thick	stos	APCI 579.2.3
2" thru 24"	Ring, Compressed Asbestos 1/16" thick		APCI 579.2.3
<u>VALVES</u>			
<u>GATE</u>			
2"	150# Bronze, Flat Face Flanged Ends		V-11F
2"	Same - Extended Bonnet		EBV-11F
2 1/2" thru 8"	150# Bronze, Flat Face Flanged Ends		V-4F
2 1/2" thru 8"	Same - Extended Bonnet		EBV-4F
10" thru 12"	150# Bronze, Flat Face Flanged Ends		V-5F
14" thru 18"	150# Cast STSTL Type 304, Raised Face Flanged Ends		V-243G
10" thru 18"	Same - Extended Bonnet		EBV-243G
GLOBE			
1/4" thru 1 1/2"	200# Bronze, Screwed		V-511A
2" thru 3"	150# Bronze, Flat Face Flanged Ends		V-511F
2" thru 3"	Same - Extended Bonnet		EBV-514F
i e e e e e e e e e e e e e e e e e e e			

	570 PIPING	AA 1.5	Page 3
COLD BOX SERVICE	+100°F AND BELOW	150 PSIG MAX OWG	ALUMINUM
ITEM	DESCRIPTION	SPECI	FICATION
<u>VALVES</u> (Cont'd)			
GLOBE (Cont'd)			
4" thru 6"	150# Bronze, Flat Face Flanged Ends	V-513F	
4" thru 6"	Same - Extended Bonnet	EBV-515F	
8" thru 12"	150# Cast STSTL Type 304, Raised Face Flanged Ends	V-743G	
8" thru 12"	Same - Extended Bonnet	EBV-743G	
ANGLE			
2" thru 3"	150# Bronze, Flat Face Flanged Ends	V-1011F	
2" thru 3"	Same - Extended Bonnet	EBV-1011F	
4" thru 6"	150# Bronze, Flat Face Flanged Ends	V-1013F	
8" thru 12"	150# Cast STSTL Type 304, Raised Face Flanged Ends	V-1243G	
4" thru 12"	Same - Extended Bonnet	EBV-1243G	
<u>CHECK</u>			
2" thru 6"	150# Bronze, Swing, Flat Fa Flanged Ends	ace V-1511F	
8" thru 12"	150# Cast STSTL Type 304, S Raised Face Flanged Ends	Swing, V-1742G	
GLOBE (FOR PRESSURI	E GAUGE AND INSTRUMENT SHUT-(OFF)	
1/4" and 1/2"	400# OWG Bronze, Needle Typ Screwed Ends (Warm Zone Onl	pe, V-2011A Ly)	



DESIGN ENGINEERING STANDARDS

571.3

Page 4 AA 1.5

570 PIPING

COLD BOX SERVICE

+100°F AND BELOW

150 PSIG MAX OWG

ALUMINUM

NOTE: 1. The use of bends to replace ells will be permitted where sound judgement indicates an application on sizes up to and including 3". For detail bend radius data, see Design Engineering Standard

571.1.1.

2. This standard can be used for temperature up to 150°F at a maximum of 140 PSIG.

- 3. Valves with a designator prefix of EBV- are Extended Bonnet Valves. These valves are to be selected from Air Products and Chemicals, Inc. Design Engineering Standards Section 579.4.
- 4. Threaded pipe is restricted to use at instruments, pressure gauges, pressure taps, and safety valve connections only.
- 5. Branch connections may be used where economically justifiable. Consult with the piping squad leader and stress analyst prior to their use.

		7/0 111110	AA) 1960	
	COLD BOX SERVIC	E +100°F AND BELOW 300 PSIG MAX	OWG ALUMINUM	
	<u>ITEM</u> PI <i>P</i> E	DESCRIPTION	SPECIFICATION	
	1/4"	XH Seamless, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM B241 6061-T6	
	1/2" thru 1 1/2"	Std. Wt. Seamless, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM B241 6061-T6	
	10" and smaller	Std. Wt. Seamless, Plain Ends	ASTM B241 6061-T6	
	12"	.375 Wall, Seamless, Plain Ends	ASTM B241 6061-T6	
	FITTINGS (See Note 5)		
	2" and smaller	Sch. 40 Forged, Socket Weld Ends	ASTM B247 6061-T6 ASA B16.11	
	2 1/2" thru 10"	Std. Wt. Wrought, Buttweld Ends	ASTM B361 WP 6061-T6 ASA B16.9	
	12"	.375 Wall, Wrought, Buttweld Ends	ASTM B361 WP 6061-T6 ASA B16.9	
	FLANGES			
	2" thru 12"	300# Forged Aluminum, Weld Neck, Flat Face, Bore for Sch. of Pipe	ASTM B247 6061-T6 ASA B16.5	
	2" thru 12"	300# Forged Aluminum, Weld Neck, Raised Face, Bore for Sch. of Pipe	ASTM B247 6061-T6 ASA B16.5	
l	BOLTING			
	All Sizes	Studs, Aluminum, Full Thd. Nuts, Hex, STSTL, Tp 321 (Alternate, STSTL, Tp 316)	ASTM B211 2024-T4 ASTM A194 Sym 8T APCI 579.2.2	
	<u>GASKETS</u>			
	2" thru 12"	Full Face, Compressed Asbestos 1/16" thick	APCI 579.2.3	N
	2" thru 12"	Ring, Compressed Asbestos 1/16" thick	APCI 579.2.3	COCHMENT
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DESIGN ENGINEERING STANDARDS

571.4 Page 2

AA 3

Page 2 AA 3)/O 1111NO	
COLD BOX SERVICE	+100°F AND BELOW 300 PSIG I	MAX OWG ALUMINUM
ITEM	DESCRIPTION	<u>SPECIFICATION</u>
VALVES		
GATE		
2" thru 3"	300# Bronze, Flat Face Flanged Ends	V-21F
2" thru 3"	Same - Extended Bonnet	EBV-21F
4" thru 12"	300# Cast STSTL Type 304, Raised Face Flanged Ends	V-253G
4" thru 12"	Same - Extended Bonnet	EBV-253G
GLOBE		
1/4" thru 1 1/2"	200# Bronze, Screwed	V-511A
2" thru 3"	300# Bronze, Flat Face Flanged Ends	V-521F
2" thru 3"	Same - Extended Bonnet	EBV-521F
4" thru 8"	300# Cast STSTL Type 304, Raised Face Flanged Ends	V-751G
4" thru 8"	Same - Extended Bonnet	EBV-751G
ANGLE		
2" thru 3 "	300# Bronze, Flat Face Flanged Ends	V-1021F
2" thru 3"	Same - Extended Bonnet	EBV-1021F
4" thru 8"	300# Cast STSTL Type 304, Raised Face Flanged Ends	V-1251G
4" tnru 8"	Same - Extended Bonnet	EBV-1251G
<u>CHECK</u>		
2" thru 3"	300# Bronze, Swing, Flat Face Flanged Ends	V-1521F
4" thru 12"	300# Cast STSTL, Type 304, Swing, Raised Face Flanged Ends	V-1751G



AA 3

COLD BOX SERVICE

+100°F AND BELOW

300 PSIG MAX OWG

ALUMINUM

ITEM

DESCRIPTION

SPECIFICATION

VALVES (Cont'd)

GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)

1/4" and 1/2"

400# OWG Bronze, Needle Type Screwed Ends (Warm Zone Only)

V-2011A

NOTE: 1.

- 1. The use of bends to replace ells will be permitted where sound judgement indicates an application on sizes up to and including 3". For detail bend radius data see Design Engineering Standard 571.1.1.
- 2. This standard can be used for temperatures up to 150°F at a maximum of 280 PSI.
- 3. Valves with a designator prefix of EBV- are Extended Bonnet Valves. These valves are to be selected from Air Products and Chemicals, Inc. Design Engineering Standards Section 579.4.
- 4. Threaded pipe is restricted to use at instruments, pressure gauges, pressure taps, and safety valve connections only.
- 5. Branch connections may be used where economically justifiable. Consult with the piping squad leader and stress analyst prior to their use.

	·	

COLD BOX SERVICE PROCESS (INSTRUMENT PIP	PING) 100°F & BELOW, 400 PSIG MAX OWG	ALUMINUM TUBE
<u>ITEM</u>	DESCRIPTION	SPECIFICATION
INSIDE COLD BOX		
TUBING	3/8" O.D. Aluminum (0.035" Wall)	ASTM B210 3003-H14 Straight
	or	
	3/8" O.D. Aluminum (0.035" Wall) (Coiled tube shall not be used in APCI Shop-manufactured Cold Boxes)	ASTM B210 3003-0, Coiled
(For Analyzer Taps)	3/8" O.D. Aluminum (0.065" Wall) (0.065" Wall is mandatory for analyzer taps)	ASTM B210 6061-T6, Straight
<u>FITTINGS</u>		
ELLS	None (use bends)	
COUPLING	3/8" O.D. x 3/8" O.D., Aluminum Union, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	
ADAPTER (At STSTL Line)	3/8" O.D. x 1/4" IPS, Type 316 STSTL, Buttweld Male Connector to Flareless Joint, Swagelok, Gyrolok or Parker C.P.I.	
ADAPTER (At Copper Tube Line)		
TUBING	3/8" O.D. Copper (0.030" Wall) Type L (Drill 0.389/0.381" Dia. Hole & Silver Braze)	ASTM B88, Annealed Straight
ADAPTER (At Aluminum Line)		
COUPLING	1/2" FNPT 2000# Forged Aluminum Coupling or Thredolet	ASTM B247 6061-T6 ASA B16.11
CONNECTOR	3/8" O.D. x 1/2" MNPT, Aluminum Male Connector Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	

IAA 4

570 PIPING

COLD BOX SERVICE

PROCESS (INSTRUMENT PIPING) 100°F & BELOW, 400 PSIG MAX OWG ALUMINUM TUBE

ITEM

DESCRIPTION

SPECIFICATION

OUTSIDE COLD BOX

ADAPTER

3/8" O.D. x 1/4" FNPT, Aluminum

(At Jacket)

Bulkhead Female Connector, Flareless

Type, Swagelok, Gyrolok, or Parker C.P.I.

ADAPTER

Steel, Bulkhead Retainer (For use

with Bulkhead Female Connector),

Swagelok, Gyrolok, or Parker C.P.I.

NIPPLE

1/4" Brass Hex

Kerotest U-10 or

Equal

FITTINGS

1/4" FNPT, 250# Cast

ASTM B62

Brass, Screwed Ends

VALVES

Globe

1/4", 400# OWG, Bronze

V2011A

Screwed Ends

NOTE: 1. Ells shall not be used inside the cold box. Only bends are permitted.

- 2. Installation of flareless fittings shall be in strict accordance with manufacturer's instructions.
- 3. Before tightening external bulkhead nut, caulk bulkhead female connector with Dow-Corning Silastic 732 RTV adhesive sealant to provide suitable jacket seal.

P	570 PIPING	IAA 9	Page 1
COLD BOX SERVICE PROCESS (INSTRUMENT PIPE	ENG) 100°F & BELOW, 900 PSIG MA	X OWG ALUMINU	M TUBE
<u>ITEM</u>	DESCRIPTION	SPECIFI	CATION
INSIDE COLD BOX			
TUBING	3/8" O.D. Aluminum (0.035" Wall	ASTM B2 Straigh	210 300 3 Hl nt
	3/8" O.D. Aluminum (0.035" Wall (Coiled tube shall not be used APCI Shop-manufactured Cold Box	in Coiled	210 3003-0
(For Analyzer Taps)	3/8" O.D. Aluminum (0.065" Wall (0.065" Wall is mandatory for analyzer taps)	ASTM B2 Straigh	210 6061-T6
<u>FITTINGS</u>			
ELLS	None (use bends)		
COUPLING	3/8" O.D. x 3/8" O.D., Aluminum Flareless Type, Swagelok, Gyrol Parker C.P.I.		
ADAPTER (At STSTL Line)	3/8" O.D. x 1/4" IPS, Type 316 Buttweld Male Connector to Flar Joint, Swagelok, Gyrolok, or Pa C.P.I.	eless	
ADAPTER (At Aluminum Line)			
COUPLING	1/2" FNPT 2000# Forged Aluminum Coupling or Thredolet	ASTM B2 ASA B16	47 6061-T6
CONNECTOR	3/8" O.D. x 1/2" MNPT, Aluminum Male Connector, Flareless Type, Swagelok, Gyrolok, or Parker C.		
OUTSIDE COLD BOX			
<u>ADAPTER</u> (At Jacket)	3/8" O.D. x 1/4" FNPT, Aluminum Bulkhead Female Connector, Flar Type, Swagelok, Gyrolok, or Par C.P.I.	eless	

Steel, Bulkhead Retainer (For use

with Bulkhead Female Connector), Swagelok, Gyrolok, or Parker C.P.I.

DESIGN ENGINEERING STANDARDS

570 PIPING

IAA 9

COLD BOX SERVICE 100°F & BELOW, 900 PSIG MAX OWG ALUMINUM TUBE PROCESS (INSTRUMENT PIPING) SPECIFICATION DESCRIPTION ITEM OUTSIDE COLD BOX (Cont'd.) ASTM A312 Tp 304 1/4" Sch. 80S, Seamless, Threaded PIPE Ends 1/4" FNPT, 2000# Forged STSTL, ASTM A182 F304 FITTINGS ASA B16.11 Screwed Ends

VALVES

Globe 1/4", 3000# OWG, Type 304 or 316 V-719A STSTL, Screwed Ends

NOTE: 1. Ells shall not be used inside the cold box. Only bends are permitted.

- 2. Installation of flareless fittings shall be in strict accordance with manufacturer's instructions.
- 3. Before tightening external bulkhead nut, caulk bulkhead female connector with Dow-Corning Silastic 732 RTV adhesive sealant to provide suitable jacket seal.